# SECTION 00 01 00 – TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Division</th>
<th>Section Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS</strong></td>
<td></td>
</tr>
<tr>
<td>00 01 00</td>
<td>TABLE OF CONTENTS</td>
</tr>
<tr>
<td>00 01 25</td>
<td>INTRODUCTION TO GUIDELINES</td>
</tr>
<tr>
<td>00 73 46</td>
<td>WAGE DETERMINATION SCHEDULE</td>
</tr>
<tr>
<td><strong>DIVISION 01 - GENERAL REQUIREMENTS</strong></td>
<td></td>
</tr>
<tr>
<td>01 00 00</td>
<td>GENERAL REQUIREMENTS</td>
</tr>
<tr>
<td>01 10 00</td>
<td>SUMMARY</td>
</tr>
<tr>
<td>01 18 00</td>
<td>PROJECT UTILITY SOURCES</td>
</tr>
<tr>
<td>01 21 00</td>
<td>ALLOWANCES</td>
</tr>
<tr>
<td>01 22 00</td>
<td>UNIT PRICES</td>
</tr>
<tr>
<td>01 23 00</td>
<td>ALTERNATES</td>
</tr>
<tr>
<td>01 25 00</td>
<td>SUBSTITUTION PROCEDURES</td>
</tr>
<tr>
<td>01 26 00</td>
<td>CONTRACT MODIFICATION PROCEDURES</td>
</tr>
<tr>
<td>01 29 00</td>
<td>PAYMENT PROCEDURES</td>
</tr>
<tr>
<td>01 31 00</td>
<td>PROJECT MANAGEMENT AND COORDINATION</td>
</tr>
<tr>
<td>01 32 00</td>
<td>CONSTRUCTION PROGRESS DOCUMENTATION</td>
</tr>
<tr>
<td>01 32 33</td>
<td>PHOTOGRAPHIC DOCUMENTATION</td>
</tr>
<tr>
<td>01 33 00</td>
<td>SUBMITTAL PROCEDURES</td>
</tr>
<tr>
<td>01 35 44</td>
<td>SPECIAL PROCEDURES FOR ENVIRONMENTAL HEALTH AND SAFETY AND FIRE AND LIFE SAFETY</td>
</tr>
<tr>
<td>01 35 46</td>
<td>INDOOR AIR QUALITY PROCEDURES</td>
</tr>
<tr>
<td>01 35 46A</td>
<td>INDOOR AIR QUALITY PROCEDURES - APPENDIX A: IAQ PLAN</td>
</tr>
<tr>
<td>01 35 96</td>
<td>SPECIAL PROCEDURES FOR PROPERTY PROTECTION</td>
</tr>
<tr>
<td>01 40 00</td>
<td>QUALITY REQUIREMENTS</td>
</tr>
<tr>
<td>01 41 00</td>
<td>REGULATORY REQUIREMENTS</td>
</tr>
<tr>
<td>01 42 00</td>
<td>REFERENCES</td>
</tr>
<tr>
<td>01 50 00</td>
<td>TEMPORARY FACILITIES AND CONTROLS</td>
</tr>
<tr>
<td>01 60 00</td>
<td>PRODUCT REQUIREMENTS</td>
</tr>
<tr>
<td>01 73 00</td>
<td>EXECUTION</td>
</tr>
<tr>
<td>01 74 19</td>
<td>CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL</td>
</tr>
<tr>
<td>01 74 19A</td>
<td>APPENDIX A - FORM CWM-1: CONSTRUCTION WASTE IDENTIFICATION</td>
</tr>
<tr>
<td>01 74 19B</td>
<td>APPENDIX B - FORM CWM-2: DEMOLITION WASTE IDENTIFICATION</td>
</tr>
<tr>
<td>01 74 19C</td>
<td>APPENDIX C - FORM CWM-3: CONSTRUCTION WASTE REDUCTION WORK PLAN</td>
</tr>
<tr>
<td>01 74 19D</td>
<td>APPENDIX D - FORM CWM-4: DEMOLITION WASTE REDUCTION WORK PLAN</td>
</tr>
<tr>
<td>01 74 19G</td>
<td>APPENDIX G - FORM CWM-7: CONSTRUCTION WASTE REDUCTION PROGRESS REPORT</td>
</tr>
<tr>
<td>01 74 19H</td>
<td>APPENDIX H - FORM CWM-8: DEMOLITION WASTE REDUCTION PROGRESS REPORT</td>
</tr>
<tr>
<td>01 77 00</td>
<td>CLOSEOUT PROCEDURES</td>
</tr>
<tr>
<td>01 77 00A</td>
<td>CLOSEOUT PROCEDURES - APPENDIX A: SUPPLEMENTAL NOTICE OF OCCUPANCY AND USE LIST</td>
</tr>
<tr>
<td>01 77 00B</td>
<td>CLOSEOUT PROCEDURES - APPENDIX B: SUPPLEMENTAL BUILDING / PROJECT ACCEPTANCE LIST</td>
</tr>
</tbody>
</table>
01 78 23  OPERATION AND MAINTENANCE DATA
01 78 39  PROJECT RECORD DOCUMENTS
01 78 46  EXTRA STOCK MATERIALS
01 79 00  DEMONSTRATION AND TRAINING
01 81 13  SUSTAINABLE DESIGN REQUIREMENTS

DIVISION 02 - EXISTING CONDITIONS

02 81 00  TRANSPORTATION/DISPOSAL OF HAZARDOUS MATERIAL

DIVISION 03 - CONCRETE

03 30 00  CAST-IN-PLACE CONCRETE
03 38 16  UNBONDED POST-TENSIONED CONCRETE

DIVISION 04 - MASONRY

04 01 20  MAINTENANCE OF UNIT MASONRY
04 20 00  UNIT MASONRY

DIVISION 05 - METALS

05 31 00  STEEL DECKING
05 40 00  COLD-FORMED METAL FRAMING
05 51 00  METAL STAIRS
05 73 00  DECORATIVE METAL RAILINGS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06 10 53  MISCELLANEOUS ROUGH CARPENTRY
06 16 00  SHEATHING
06 20 23  INTERIOR FINISH CARPENTRY
06 41 00  ARCHITECTURAL WOOD CASEWORK
06 42 16  FLUSH WOOD PANELING

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 10 00  DAMPROOFING AND WATERPROOFING
07 18 00  TRAFFIC COATINGS
07 21 00  THERMAL INSULATION
07 24 00  EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS)
07 27 00  AIR BARRIERS
07 42 13  METAL WALL PANELS
07 50 00  MEMBRANE ROOFING
07 55 63  VEGETATED PROTECTED MEMBRANE ROOFING
07 62 00  SHEET METAL FLASHING AND TRIM
07 72 00  ROOF ACCESSORIES
07 81 00  APPLIED FIREPROOFING
07 92 00  JOINT SEALANTS
DIVISION 08 - OPENINGS

08 00 00 OPENINGS
08 11 13 HOLLOW METAL DOORS AND FRAMES
08 14 16 FLUSH WOOD DOORS
08 30 00 SPECIALTY DOORS AND FRAMES
08 41 13 ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
08 44 00 CURTAIN WALL AND GLAZED ASSEMBLIES
08 51 13 ALUMINUM WINDOWS
08 71 00 DOOR HARDWARE
08 80 00 GLAZING

DIVISION 09 - FINISHES

09 00 00 FINISHES
09 22 16 NON-STRUCTURAL METAL FRAMING
09 29 00 GYPSUM BOARD
09 30 00 TILING
09 51 13 ACOUSTICAL PANEL CEILINGS
09 61 19 VAPOR EMISSION AND ALKALINITY CONTROL FLOORING TREATMENT
09 65 00 RESILIENT FLOORING
09 67 23 RESINOUS FLOORING
09 68 13 TILE CARPETING
09 68 16 SHEET CARPETING
09 72 00 WALL COVERINGS
09 77 33 PLASTIC WALL SURFACING
09 91 23 INTERIOR PAINTING
09 96 00 HIGH-PERFORMANCE COATINGS

DIVISION 10 - SPECIALTIES

10 11 00 VISUAL DISPLAY UNITS
10 14 00 SIGNAGE
10 21 13 TOILET COMPARTMENTS
10 26 23 PROTECTIVE WALL COVERINGS
10 28 00 TOILET, BATH, AND LAUNDRY ACCESSORIES
10 43 13 DEFIBRILLATOR CABINETS
10 44 00 FIRE PROTECTION SPECIALTIES
10 55 00 POSTAL SPECIALTIES

DIVISION 11 - EQUIPMENT

11 00 00 EQUIPMENT
11 24 23 FACADE ACCESS EQUIPMENT
11 53 00 LABORATORY EQUIPMENT
**DIVISION 12 - FURNISHINGS**

- 12 20 00 WINDOW TREATMENTS
- 12 35 53 LABORATORY CASEWORK
- 12 46 00 FURNISHING ACCESSORIES
- 12 48 00 RUGS AND MATS
- 12 61 00 FIXED AUDIENCE SEATING
- 12 93 00 SITE FURNISHINGS

**DIVISION 13 - SPECIAL CONSTRUCTION**

- 13 11 00 SWIMMING POOLS
- 13 20 00 SPECIAL PURPOSE ROOMS

**DIVISION 14 - CONVEYING EQUIPMENT**

- 14 20 00 ELEVATORS

**DIVISION 21 - FIRE SUPPRESSION**

- 21 05 00 FIRE SUPPRESSION

**DIVISION 22 - PLUMBING**

- 22 30 00 PLUMBING EQUIPMENT

**DIVISION 23 - HEATING VENTILATING AND AIR CONDITIONING**

- 23 00 00 PLUMBING, HEATING VENTILATING AND AIR CONDITIONING (HVAC)
- 23 05 13 MOTORS
- 23 05 19 METERS AND GAUGES
- 23 05 23 GENERAL-DUTY VALVES FOR PIPING
- 23 05 53 IDENTIFICATION FOR PIPING AND EQUIPMENT
- 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC
- 23 07 00 INSULATION
- 23 08 00 COMMISSIONING OF HVAC
- 23 09 00 INSTRUMENTATION AND CONTROLS
- 23 09 13 INSTRUMENTATION AND CONTROL DEVICES
- 23 09 93 SEQUENCE OF OPERATIONS FOR HVAC CONTROLS
- 23 20 00 PIPING
- 23 21 00 HYDRONIC SYSTEMS
- 23 21 13 PRE-INSULATED PIPING
- 23 21 16 PIPING SPECIALTIES
- 23 21 23 PUMPS
- 23 22 13 STEAM AND CONDENSATE HEATING PIPING
- 23 25 01 CHEMICAL WATER TREATMENT - START-UP
- 23 25 13 CHEMICAL WATER TREATMENT
- 23 30 00 HVAC AIR DISTRIBUTION
# Table of Contents

### Division 23 - HVAC Systems
- 23 40 00 HVAC Fans
- 23 52 00 Heat Boilers
- 23 57 00 Heat Exchangers
- 23 60 00 Laboratory Piping Systems
- 23 64 16 Centrifugal Water Chillers
- 23 65 00 Cooling Towers
- 23 70 00 Central HVAC Equipment
- 23 76 00 Evaporative Air-Cooling Equipment

### Division 26 - Electrical
- 26 00 00 Electrical
- 26 05 00 Common Work Results for Electrical
- 26 05 13 Medium-Voltage Cables
- 26 05 19 Low-Voltage Electrical Power Conductors and Cables
- 26 05 26 Grounding and Bonding for Electrical Systems
- 26 05 29 Hangers and Supports for Electrical Systems
- 26 05 33 Raceway and Boxes for Electrical Systems
- 26 05 43 Underground Ducts and Raceways for Electrical Systems
- 26 05 53 Identification for Electrical Systems
- 26 09 43 Network Lighting Controls
- 26 20 00 Low Voltage Electrical Distribution
- 26 21 00 Medium-Voltage Transformers
- 26 22 00 Low-Voltage Transformers
- 26 27 13 Electrical Metering
- 26 27 26 Wiring Devices
- 26 32 13 Diesel Engine Driven Generator Sets
- 26 33 53 Static Uninterruptible Power Supply
- 26 41 13 Lightning Protection for Structures
- 26 51 00 Interior Lighting
- 26 56 00 Exterior Lighting

### Division 27 - Communications
- 27 00 00 Communications
- 27 05 00 Common Work Results for Communications
- 27 05 26 Grounding and Bonding for Communications
- 27 05 27 Communications Spaces
- 27 05 28 Pathways for Communications Systems
- 27 05 43 Outside Plant for Communications
- 27 32 53 Emergency Telephones
- 27 40 00 Audio-Video Systems
- 27 51 00 Distributed Audio-Video Communication Systems
- 27 53 19 Distributed Antenna System (DAS)
- 27 62 01 Data Center
DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

28 00 00  ELECTRONIC SAFETY AND SECURITY
28 13 00  ACCESS CONTROL
28 23 00  VIDEO SURVEILLANCE
28 31 00  FIRE DETECTION AND ALARM

DIVISION 31 - EARTHWORK

31 10 00  SITE CLEARING AND SITE GRADING
31 20 00  EARTH MOVING

DIVISION 32 - EXTERIOR IMPROVEMENTS

32 00 00  EXTERIOR IMPROVEMENTS
32 10 00  BASES, BALLASTS, AND PAVING
32 84 00  PLANTING IRRIGATION
32 92 00  TURF AND GRASSES
32 93 00  PLANTS

DIVISION 33 - UTILITIES

33 05 00  COMMON WORK RESULTS FOR UTILITIES
33 40 00  STORM DRAINAGE UTILITIES

END OF SECTION 00 01 00
PART 1 - GENERAL

1.1 INTRODUCTION TO DIVISION 01 “GENERAL REQUIREMENTS” MASTER SPECIFICATION

A. Specification Master: The University has prepared a complete Division 01 “General Requirements” master specification required for use on all University projects by Architects, Engineers, and other Design Professionals who provide design services for the University. The master specification has been written to provide a consistent set of general requirements from project to project. They represent the University’s preferred administrative and procedural requirements and are coordinated with State of Colorado Contracts for Construction and General Conditions.

B. Denver Campus and Anschutz Medical Campus: There are a number of procedures and requirements that differ between the Denver and Anschutz Medical Campuses. As such, the University has developed a unique master for each campus. The Design Professional should take care to obtain the correct campus specific master from the University Project Manager.

C. Editing Division 01 Master Specifications: It is the intent of these masters to require a minimum amount of editing; however, in all cases some editing will be required to reflect project specific conditions and requirements.

1. Obtaining master specification: The University Project Manager will provide the Design Professional with an editable copy of the Division 01 master in Microsoft Word format.

2. Editor’s notes: Editor’s notes are found throughout the text where the Design Professional is required to make a choice and/or edit the subsequent paragraph(s) in the Section Text based on project specific requirements. Editor’s notes are indicated by Blue, Arial 8pt font surrounded by a thin black line as indicated below. Delete the editor’s notes after making the indicated edits.

3. Options: Optional selections in the Section Text are indicated by a bold font surrounded by brackets. To edit the option, delete all text that is not applicable, remove brackets from around the applicable choice, and change font from bold to normal face. The following is an example of what an editor’s note and optional text look like in the Section Text.

Retain one of the three options in the subparagraph below based on project delivery method: Design/Bid/Build, CMGC, or Design/Build.

a. [Contractor’s Agreement Design/Bid/Build, State Form SC-6.21 and The General Conditions of the Construction Contract Design/Bid/Build, State Form SC-6.23]  
   [Construction Manager/General Contractor Agreement CMGC, State Form SC-6.4]  
   [Design/Build Agreement, State Form SC-8.0 and The General Conditions of the Design/Build Agreement, State Form SC-8.1] for definitions and contractual requirements related to contract modification procedures.

4. Format: Do not change format, including but not limited to font typeface and size, page margins, header and footer layout, outline numbering and indents.

a. Outline numbering: The document template is set up so that outline numbering is automatic. Use the “Decrease Indent” and “Increase Indent” buttons on the “Paragraph” menu to demote or promote a paragraph in the outline respectively.
INTRODUCTION TO GUIDELINES

b. Styles: Automatic numbering, formatting and indents are controlled by the use of Styles within the Microsoft Word document. It is suggested that the editor become familiar with this software capability before editing.

1) Warning: Do not cut and paste text from another document into the master unless familiar with software capability to change Styles. Imported text carries with it Styles from the document of origin and will damage the auto-numbering capability of the template unless the appropriate document styles are applied after inserting.

2) Hierarchy of styles: The following is the hierarchy of styles within each document:

   PRT (PART 1)
   ART (1.1)
   PR1 (A.)
   PR2 (1.)
   PR3 (a.)
   PR4 (1)
   PR5 (a)

3) Section Title and End of Section: Styles for these are SCT and EOS respectively.

D. Sustainable Design: For projects required to obtain LEED certification, the Design Professional in conjunction with the University Project Manager is required to develop project specific Section 01 81 13 “Sustainable Design Requirements” and Section 01 91 13 “General Commissioning Requirements” for inclusion into Division 01. A Section master is provided for Section 01 74 19 “Construction Waste Management and Disposal.” This section should be included in Division 01 only for projects pursuing LEED certification.

E. Commissioning: The University may choose to engage a Commissioning Agent (CxA) and provide commissioning on projects, even if not pursuing LEED certification. Coordinate project commissioning requirements with University Project Manager and, if required, develop Section 01 91 13 "General Commissioning Requirements" for inclusion in Division 01. Coordinate general commissioning requirements with other required commissioning activities indicated in Mechanical and Electrical Sections, including but not limited to testing and balancing and equipment startup requirements.

F. Large Project versus Small Project: There are a number of options in the Section Text that distinguish between a large project and a small project. Make the appropriate selection in consultation with University Project Manager. In general, small projects are those with a construction budget of less than $500,000.

1.2 INTRODUCTION TO DIVISION 02 – 33 GUIDELINES

A. Guidelines: The University has prepared these Guidelines for the benefit and use of Architects, Engineers, and other Design Professionals who provide design services for the University. Divisions 02 through 33 are not intended to be project specifications, nor do they cover all materials and systems which may be required for any given project. These Guidelines represent the University's preferences for the various systems and materials indicated but may not be suitable in all cases. They represent a minimum acceptable level of quality and in some cases indicate preferred and/or required material manufacturers to be used on all projects. Any deviations from this Guideline shall be clearly identified in writing and approved by the University.

B. University Materials Preferences: In order to be concise and useful to the Design Professional, the Guidelines focus only on materials, systems and/or standards where the University has a preference or where the University standard is higher than that typically accepted within the design and construction process.
industry. In all other cases, it is the Design Professional’s responsibility to select and specify appropriate industry standards to govern the fabrication and installation of the work. For example, in SECTION 03 30 00 – CAST-IN-PLACE CONCRETE, the Guidelines do not list ACI 301 – Specification for Structural Concrete as a reference standard because it is expected that the Design Professional would include this reference standard as a customary matter of practice without direction to do so by the Guidelines.

1.3 Designer-of-Record Responsibility

A. Notwithstanding the above, the Architect, Engineer, or other Design Professional using this Specification Master and Guideline understands that they alone are the professional designer of record and wholly responsible for the incorporation and/or specification of any and all selections of either systems, components, materials, and/or manufacturers as may be required and appropriate for the design. The Design Professional is both required and expected to evaluate the suitability of all materials and systems indicated herein for the purpose intended. They alone shall be considered as author of and fully responsible for the entire design. No claim shall be made of or considered by the University or any of its Consultants who assisted the University in authoring these Guidelines related to any design defect alleged to have resulted from the Design Professionals compliance with these Guidelines. By accepting and using these Guidelines the Design Professional acknowledges the above and the limitations indicated therein.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 00 01 25
SECTION 00 73 46 - WAGE DETERMINATION SCHEDULE

PART 1 - GENERAL

1.1 DAVIS-BACON WAGE DETERMINATIONS

   A. Coordinate with the University Project Manager to determine if applicable.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 00 73 46
SECTION 01 00 00 - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Design Requirements:
   1. Designer Responsibility: Based on a series of meetings with the University Project Manager and applicable University staff, draft Division 01 Specification Sections consistent with State of Colorado Construction Contract provisions, General and Supplementary Conditions of the Contract, including requirements for administrative procedures consistent with the size and scope of the project.
   2. Content: Include, as applicable, the following Sections:
      a. SECTION 01 00 00 – SUMMARY.
      b. SECTION 01 25 00 – SUBSTITUTION PROCEDURES.
      c. SECTION 01 26 00 – CONTRACT MODIFICATION PROCEDURES.
      d. SECTION 01 31 00 – PROJECT MANAGEMENTS AND COORDINATION.
      e. SECTION 01 32 33 – PHOTOGRAPHIC DOCUMENTATION.
      f. SECTION 01 33 00 – SUBMITTAL PROCEDURES.
      g. SECTION 01 35 00 – SPECIAL PROCEDURES.
         1) This Section includes special environment health and safety procedures unique to work at University projects.
      h. SECTION 01 35 46 – INDOOR AIR QUALITY PROCEDURES
         1) This Section includes special procedures required by the University to maintain a high level of indoor air quality both during construction and subsequent to occupancy.
      i. SECTION 01 40 00 – QUALITY REQUIREMENTS.
      j. SECTION 01 41 00 – REGULATORY REQUIREMENTS.
      k. SECTION 01 42 00 – REFERENCES.
      l. SECTION 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
      m. SECTION 01 60 00 – PRODUCT REQUIREMENTS.
      n. SECTION 01 73 00 – CLOSEOUT PROCEDURES.
      o. SECTION 01 74 19 – CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL.
      p. SECTION 01 78 23 – OPERATION AND MAINTENANCE DATA.
      q. SECTION 01 78 39 – PROJECT RECORD DOCUMENTS.
      r. SECTION 01 78 46 – EXTRA STOCK MATERIALS.
      s. SECTION 01 79 00 – DEMONSTRATION AND TRAINING.
      t. SECTION 01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS.
      u. SECTION 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01 00 00
SECTION 01 10 00

SUMMARY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Project information.
2. Work covered by Contract Documents.
3. Work by University.
4. Work under separate contracts.
5. University-furnished and installed products.
7. Access to site.
8. Coordination with occupants.
10. Specification and drawing conventions.

B. Related Requirements:

1. Section 01 35 46 "Indoor Air Quality Procedures" for requirements and procedures related to maintaining air quality in adjacent occupied spaces and buildings.
2. Section 01 50 00 "Temporary Facilities and Controls" for limitations and procedures governing temporary use of University's facilities and for the provision of temporary construction barriers and dust partitions.

Complete "Project Information" Article below based on project-specific information.

1.3 PROJECT INFORMATION

A. Project Identification: <Insert Project identifier such as Project name and number>.

1. Project Location: <Insert Project location (street address, city, and state)>.

B. Principal Representation: University of Colorado Denver.

1. University's Representative: <Insert name and contact information for University's representative>.

C. Architect/Engineer: <Insert name and contact information for Architect/Engineer>.
D. Architect/Engineer's Consultants: The Architect/Engineer has retained the following design professionals who have prepared designated portions of the Contract Documents:

Copy and re-edit subparagraph below for each consultant.

1. <Insert title of design discipline>: <Insert name and contact information for consultant>.

E. Other University Consultants: The University has retained the following design professionals who have prepared designated portions of the Contract Documents:

Copy and re-edit subparagraph below for each consultant.

1. <Insert title of design discipline>: <Insert name and contact information for consultant>.  
   <Insert title of design discipline> has prepared the following portions of the Contract Documents:
   a. <Insert description of scope of service for other University consultant>.

F. Project Web Site:  A project Web site administered by Contractor will be used for purposes of managing communication and documents during the construction stage.

1. See Section 01 31 00 "Project Management and Coordination." for requirements for establishing administering and using the Project Web site.

1.4 WORK COVERED BY CONTRACT DOCUMENTS

In first paragraph below, include an abbreviated description of the Work for Project identified in "Project Information" Article. See Evaluations. For single prime contracts, this article may be eliminated.

A. The Work of Project is defined by the Contract Documents and, in summary, briefly consists of the following:

1. <Insert a brief description of Project indicating the size, code classification for occupancy and construction type, and general description of major building assemblies>.

1.5 WORK BY UNIVERSITY

A. General: Cooperate fully with University so work may be carried out smoothly, without interfering with or delaying work under this Contract or work by University. Coordinate the Work of this Contract with work performed by University.
1.6 WORK UNDER SEPARATE CONTRACTS

A. General: Cooperate fully with separate contractors so work on those contracts may be carried out smoothly, without interfering with or delaying work under this Contract or other contracts. Coordinate the Work of this Contract with work performed under separate contracts.

1.7 UNIVERSITY-FURNISHED AND INSTALLED PRODUCTS

A. University will furnish certain items of equipment/furnishings as shown on the Drawings. Contractor will be responsible for coordinating their work to accommodate these items including, but not limited to, physical space fit, utility connections and rough-in, power wiring and electrical characteristics.

B. Include in Project scheduling the latest times when information for such items is required and so notify the University in writing.

1.8 UNIVERSITY-FURNISHED, CONTRACTOR-INSTALLED PRODUCTS

A. The University will furnish certain items delivered to the jobsite as shown on the drawings. Contractor will receive, unload, move, set in position, anchor and connect such items and put them into operating condition.

B. The Contractor will be responsible for coordinating their work to accommodate these items including, but not limited to, physical space fit, utility connections and rough-in, power wiring and electrical characteristics.

C. Include in Project scheduling the latest times when information for such items is required and so notify the University in writing.

D. Cooperate with University in scheduling the delivery of these items and be responsible for accommodating their storage and protection in the building and their replacement or repair due to damage as a result of Contractor’s operations.

1.9 ACCESS TO SITE

A. General: Contractor shall have limited and restricted use of Project site for construction operations as indicated on Drawings by the Contract limits and as indicated by requirements of this Section.

B. Use of Site: Limit use of Project site to areas within the Contract limits indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.

   1. Adjust means and methods of construction based on site limits and restrictions.
   2. Locate staging areas only where permitted by University.
   3. As part of this Project, replace damaged lawns, sprinkler systems, sidewalks and any other existing site improvements within staging area and access ways.

C. Construction Access and Travel:

   1. Use only those entrances, exits, and travel ways on campus roads and within the building designated by University. Contractor's personnel are not permitted in non-designated areas of
University’s existing facilities. Use only designated travel ways for transporting demolition materials, new construction materials, tools and equipment.

2. Use of other than designated travel ways on campus roads and within existing buildings requires a minimum of 20 business days prior approval by University.
   a. Request variations to traffic flow including temporary fire lane, parking lot, sidewalk and road closures, regulatory signage, and traffic control devices in accordance with City and County of Denver requirements.

3. Access to the site will be as permitted by the University. Prearrange delivery and use of cranes, heavy trucks and other heavy equipment at least 72 hours prior to need through the University’s Project Manager and University Police.

4. Maintain access to fire lanes and campus operations at all times. Provide flag personnel during the ingress or egress of large equipment.
   a. When fire lanes and/or access way must be temporarily disrupted notify University Police and University Parking and Transportation at least 20 business days in advance and reconfirm 72 hours in advance through the University’s Project Manager.

5. Arrange for and obtain all necessary permits from City and County of Denver for any disruption to or temporary closures of public city streets. Coordinate procurement of permits with University Project Manager.

D. Construction Parking:

1. General: Contractor parking will not be provided; make arrangements and pay for all required parking.

2. Provide temporary parking or use designated areas of University’s existing parking areas as applicable to the Project and in accordance with the following:
   a. All parking on University property, including parking on University owned streets, is under the exclusive control and authority of University Parking and Transportation Services. Direct policy question to the department at (303) 724-2555.
   b. There is no free parking on campus. Displacement or use of existing parking spaces by Contractor, either for parking or for staging, is a Contractor cost.
   c. Use of existing parking spaces or other areas outside of Contractor’s staging area must be approved in advance by University Parking and Transportation Services.
   d. University Parking and Transportation Services may require and issue parking permits through the University Project Manager. Permits must be displayed and visible at all times while parked on the campus. Failure to display a permit will result in citations being written and possible removal of the vehicle from University property.
   e. Keep all designated parking areas clean and free of litter and debris. University reserves the right to direct Contractor to clean areas not kept clean and orderly.
   f. University Parking and Transportation Services may change parking assignments as deemed necessary, restrict the use of any space(s) or lot(s) at any time, and determine the hours of control and mode of operations for any parking area at any time. University Parking and Transportation Services may deny or revoke parking privileges to any person when deemed necessary and/or considered to be in the best interests of the University.

3. Parking on University property is at the Contractor’s own risk. The University and any entity affiliated with it are not responsible for fire, theft, and damage to or loss of contractor’s or subcontractor’s vehicle or any article left therein. Only a license is granted to the user and no bailment is created.

Retain "Condition of Existing Building" Paragraph below if the Work involves existing occupied building.
E. Condition of Existing Building: Maintain portions of existing building affected by construction operations in a weathertight condition throughout construction period. Repair damage caused by construction operations.

1.10 COORDINATION WITH OCCUPANTS

A. University may occupy site and both existing and adjacent building(s) during entire construction period. Cooperate with University during construction and sequence operations to minimize conflicts and facilitate University usage. Perform the Work so as not to interfere with University's day-to-day operations.

1. Maintain existing exits from existing and adjacent building, unless otherwise indicated.
2. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from University and approval of authorities having jurisdiction.
3. Limit construction operations to those methods and procedures which will not adversely and unduly affect the working environment of University’s occupied spaces, including noise, dust, odors, air pollution, ambient discomfort, poor lighting, hazards and other undesirable effects and conditions.
4. Coordinate with University Project Manager to schedule jack hammering or activities producing dusty conditions, excessive fumes or odors during off-hours.
5. When work must be accomplished in areas containing existing furniture, upon a minimum of 3 business days notification of the University Project Manager, University will remove or relocate existing furniture.
6. Provide not less than 72 hours' notice to University Project Manager of activities that will affect University's operations. University Project Manager will coordinate with campus tenants.
   a. Refer to “Work Restrictions” Article of this Section for procedures and notification requirements related to utility interruptions.
7. Provide temporary barriers and partitions, or other means as required to protect occupants of existing building and the general public from injury due to construction activities. Prevent the spread of dust and dirt to adjacent occupied areas and building.

1.11 WORK RESTRICTIONS

A. Work Restrictions, General: Comply with restrictions on construction operations.

1. Comply with limitations on use of public streets and with other requirements of authorities having jurisdiction.
2. In planning and executing the Work, take into consideration the special needs of University patient care, teaching and research settings, for example, supply of critical utilities, noise and dust control, access to existing loading docks, occupied buildings, etc.

B. Normal Working Hours: Limit work to normal working hours of 7:00 a.m. to 7:00 p.m., Monday through Friday.

1. Notify University Project Manager of all proposed work outside of normal working hours. Include dates, times, names and contact information for contractors and subcontractor performing the Work with notification. University Project Manager will notify, as appropriate, other University personnel and departments including, but not limited to, Building Maintenance and Operations (BMO) Directors, BMO assigned representative, Campus Police and Facilities Management.
C. Noise and Vibration: Coordinate operations that may result in high levels of noise and vibration, or other disruption to University occupancy with University.

1. Noise during Normal Working Hours: Identify potentially disruptive construction activities at weekly Progress Meeting and adjust active time of day to reduce significant impacts on occupants.
2. Noise outside Normal Working Hours: Schedule construction work or demolition work outside of normal working hours with University Project Manager at minimum of 24 hours in advance.
   a. The maximum permissible noise level is 75 decibels (dBA), measured at the adjacent property line.

D. Contractor Identification:

1. Supervisory staff for the primary contractor must obtain an identification badge at the University Anschutz Medical Center (AMC) Building 500. Submit the University Access Control Badge Application form through University Project Manager. Submitted forms shall be complete with all required information including a letter on company letterhead confirming employee status with company and stating whether the company completes background testing and/or drug screening. Contractor supervision must display badge on site during construction activities.
2. To the greatest extent possible, Contractor’s and subcontractor’s employees must wear a recognizable logo shirt or hardhat identifying them as members of the contractor’s work force.
3. Work with University Project Manager and Building Maintenance and Operations staff to get identification badge activated.
4. Work with University Project Manager and Building Maintenance and Operations staff to set up identification badge for access to construction areas secured by card reader.

E. Use of Existing Elevators: Use “freight” elevators only and protect finishes during transport. Elevators may not be used for transport of construction materials between 7:00am – 9:00am, 11:30am – 1:30pm, and from 3:00pm – 5:00pm.

1. Do not block corridors, aisles, passageways or doors leading to elevator except as, and only to the extent approved by University Project Manager.

F. Keys: Submit written request to University Project Manager on University Key Request Form.

1. To the extent the need for keys is demonstrated and required to complete the Work, University Project Manager will issue keys to Contractor.
2. Contractor is responsible for all costs related to lost or non-returned keys.
3. Electrical, mechanical and sensitive research space may require University escort in lieu of issuing keys.

G. Dock Deliveries: Notify University Project Manager and limit deliver time to a maximum of 20 minutes.

H. Existing Utility Interruptions: Do not interrupt water, sewer, plumbing, gas, steam, chilled water, oxygen, HVAC, electrical power, lighting, telephone and other related utilities serving facilities occupied by University without prior notice to and approval by the University. Coordinate and schedule interruptions in advance through the University Project Manager in strict conformance with University Utility Interruption/Outage Request Procedure.

1. Form of Notice: University Utility Interruption and Start-up Request form.
2. Time of Notice: Notice for major and minor outages as defined by the Utility Interruption/Outage Request Procedure is 8 business days for minor outages and 31 business days for major outages.
I. Fire Alarm and Fire Sprinkler Interruptions: When construction activities require interruption of fire alarm or fire sprinkler service, or when dust from construction activities is likely to cause accidental alarm, advise University Project Manager who will submit an interruption request.

1. Form of Notice: University Fire Alarm/Sprinkler Disable Request Form.
2. Time of Notice: Prior to noon on the day before the anticipated interruption.

J. Nonsmoking Campus: Smoking, chewing tobacco, and other related tobacco product use is not permitted at any location on campus except outside in designated areas.

K. University Policies Applying to All Contractors: Comply with University policies applying to contractors including drug policy, sexual harassment policy and tobacco free policy. Obtain copies of University policies from University Project Manager.

1. Controlled Substances: Use of tobacco products and other controlled substances on Project site and surrounding Campus is not permitted.

L. Designated Eating Areas: Restrict consumption of food on project site to designated eating areas as approved by University Project Manager.

1.12 SPECIFICATION AND DRAWING CONVENTIONS

A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:

1. Imperative mood and streamlined language are generally used in the Specifications. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
2. Specification requirements are to be performed by Contractor unless specifically stated otherwise.
3. Words in the singular number include the plural and those in the plural include the singular.
4. Words of any gender include any other gender.

B. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.

C. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on Drawings to identify materials and products:

1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.
2. Abbreviations: Materials and products are identified by abbreviations published as part of the U.S. National CAD Standard and scheduled on Drawings.
3. Keynoting: Materials and products may be identified by reference keynotes referencing Specification Section numbers found in this Project Manual.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 10 00
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes matrix of utility sources applicable to Project.

1.3 QUALITY ASSURANCE
   A. Comply with utility company and regulatory agency codes, standards, and guidelines for the provision of new or extension of exiting utilities.

1.4 UTILITY SOURCE MATRIX
   A. The following matrix summarizes utility responsible for provision of utility service:
<table>
<thead>
<tr>
<th></th>
<th>AMC Trunk</th>
<th>AMC In Tract</th>
<th>DC Trunk</th>
<th>DC In Tract</th>
<th>AMC Trunk</th>
<th>AMC In Tract</th>
<th>DC Trunk</th>
<th>DC In Tract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>University</td>
<td>Developer</td>
<td>Xcel</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>University</td>
<td>Developer</td>
<td>NA</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Electricity</td>
<td>University</td>
<td>Developer</td>
<td>Xcel</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Storm Drainage</td>
<td>COA</td>
<td>Developer</td>
<td>DW</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Sanitary Sewer</td>
<td>COA</td>
<td>Developer</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Water</td>
<td>COA</td>
<td>Developer</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>University</td>
<td>Developer</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Xcel</td>
<td>Developer</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
<td>University</td>
</tr>
</tbody>
</table>

**University**: University of Colorado Denver  
**Note 1**: University owns Trunk steam and chilled water from CUP to vault  
**Note 2**: University owns Trunk electrical from switch gear to manhole  
**Note 3**: University owns Trunk telecom ductbank from main switch to manhole. Developer owns cable from switch to building  
**Note 4**: Xcel has license agreement with University  
**Note 5**: University and COA jointly permit

**University, TCH, UCH. In Tract lines are owned by the building they are feeding**
PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 18 00
SECTION 01 21 00
ALLOWANCES

Revise this Section by deleting and inserting text to meet Project-specific requirements.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes administrative and procedural requirements governing allowances.
   1. Certain items are specified in the Contract Documents by allowances. Allowances have been established in lieu of additional requirements and to defer selection of actual materials and equipment to a later date when direction will be provided to Contractor. If necessary, additional requirements will be issued by Change Order.
B. Types of allowances include the following:
   1. Lump-sum allowances.
   2. Unit-cost allowances.
   3. Quantity allowances.
C. Related Requirements:
   Retain subparagraph below for quantity allowances.
   1. Section 01 22 00 "Unit Prices" for procedures for using unit prices.

1.3 SELECTION AND PURCHASE
A. At the earliest practical date after award of the Contract, advise Architect/Engineer of the date when final selection and purchase of each product or system described by an allowance must be completed to avoid delaying the Work.
B. At Architect/Engineer's request, obtain proposals for each allowance for use in making final selections. Include recommendations that are relevant to performing the Work.
C. Purchase products and systems selected by Architect/Engineer from the designated supplier.
1.4 ACTION SUBMITTAGS

Retain this article because actual cost is seldom the same as allowance amount. This is good practice even if costs are identical (for example, zero-dollar Change Order).

A. Submit proposals for purchase of products or systems included in allowances, in the form specified for Change Orders.

1.5 INFORMATIONAL SUBMITTAGS

A. Submit invoices or delivery slips to show actual quantities of materials delivered to the site for use in fulfillment of each allowance.

B. Submit time sheets and other documentation to show labor time and cost for installation of allowance items that include installation as part of the allowance.

C. Coordinate and process submittals for allowance items in same manner as for other portions of the Work.

1.6 COORDINATION

A. Coordinate allowance items with other portions of the Work. Furnish templates as required to coordinate installation.

In Article title below, retain only types of allowances applicable to the Project.

1.7 [LUMP-SUM] [UNIT-COST] [AND] [QUANTITY] ALLOWANCES

For individual allowance items that include installation labor or other costs, provide detailed description of covered costs in "Schedule of Allowances" Article.

A. Allowance shall include cost to Contractor of specific products and materials ordered by University or selected by Architect/Engineer under allowance and shall include taxes, freight, and delivery to Project site.

B. Unless otherwise indicated, Contractor's costs for receiving and handling at Project site, labor, installation, overhead and profit, and similar costs related to products and materials ordered by University and/or selected by Architect/Engineer under allowance shall be included as part of the Contract Sum and not part of the allowance.

C. Unused Materials: Return unused materials purchased under an allowance to manufacturer or supplier for credit to University, after installation has been completed and accepted.

1. Unused Materials: Return unused materials purchased under an allowance to manufacturer or supplier for credit to University, after installation has been completed and accepted.

1. If requested by Architect/Engineer, retain and prepare unused material for storage by University. Deliver unused material to University's storage space as directed.

1.8 ADJUSTMENT OF ALLOWANCES

A. Allowance Adjustment: To adjust allowance amounts, prepare a Change Order proposal based on the difference between purchase amount and the allowance, multiplied by final measurement of work-in-
place where applicable. If applicable, include reasonable allowances for cutting losses, tolerances, mixing wastes, normal product imperfections, and similar margins.

1. Include installation costs in purchase amount only where indicated as part of the allowance.

Delete both subparagraphs below if no unit-cost allowances.

2. Submit substantiation of a change in scope of work, if any, claimed in Change Orders related to unit-cost allowances.
3. University reserves the right to establish the quantity of work-in-place by independent quantity survey, measure, or count.

B. Submit claims for increased costs because of a change in scope or nature of the allowance described in the Contract Documents, whether for the purchase order amount or Contractor's handling, labor, installation, overhead, and profit.

1. Do not include Contractor's or subcontractor's indirect expense in the Change Order cost amount unless it is clearly shown that the nature or extent of work has changed from what could have been foreseen from information in the Contract Documents.
2. No change to Contractor's indirect expense is permitted for selection of higher- or lower-priced materials or systems of the same scope and nature as originally indicated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine products covered by an allowance promptly on delivery for damage or defects. Return damaged or defective products to manufacturer for replacement.

3.2 PREPARATION

A. Coordinate materials and their installation for each allowance with related materials and installations to ensure that each allowance item is completely integrated and interfaced with related work.

3.3 SCHEDULE OF ALLOWANCES

The sample schedule of allowances below illustrates several types of common occurrences where allowances enable deferred design or indeterminate scope elements to be bid under lump-sum contracts. Revise to suit Project.

Sample quantity allowances in "Allowance No. 1" paragraph below illustrates one approach to applying allowances to work that cannot be measured prior to bidding, but can be reasonably anticipated.

A. Allowance No. 1: Quantity Allowance: Include 2000 cu. yd. of unsatisfactory soil excavation and disposal off-site and replacement with satisfactory soil material from off-site, as specified in Section 31 20 00 "Earth Moving."

Subparagraph below addresses relationship to unit prices.
1. Coordinate quantity allowance adjustment with unit-price requirements in Section 01 22 00 "Unit Prices."

Sample lump-sum allowance in "Allowance No. 2" Paragraph below includes a stipulation that cost items ordinarily included in the Contract Sum are to be included in the allowance cost for this item only.

B. Allowance No. 2: Lump-Sum Allowance: Include the sum of $30,000 for three chandeliers for the main lobby as specified in Section 26 51 00 "Interior Lighting."

1. This allowance includes material cost, receiving, handling, and installation, and Contractor overhead and profit.

Sample unit-cost allowance in "Allowance No. 3" Paragraph below is a typical industry practice but one which can result in significant variations in bids due to differences in quantity survey calculations.

C. Allowance No. 3: Unit-Cost Allowance: Include the sum of $350.00 per thousand for buff-colored face brick as specified in Section 04 20 00 "Unit Masonry" and as shown on Drawings.

Sample quantity allowance in "Allowance No. 4" Paragraph below illustrates practice for both new construction and tenant allowances. Carpet and cushion type can affect installation labor costs.

D. Allowance No. 4: Quantity Allowance: Include 5000 sq. yd. of Carpet Type 1 installed, including urethane foam carpet cushion and related amount of tackless strip, as specified in Section 09 68 16 "Sheet Carpeting."

Copy and re-edit "Allowance No. (Insert number)" Paragraph below for each allowance required for Project.

E. Allowance No. <Insert number>: [Lump-Sum] [Unit-Cost] [Quantity] [Contingency] [Testing and Inspecting] Allowance: Include the sum of <Insert dollar or quantity amount of allowance>: Include <Insert allowance description> as specified in Section <Insert Section number> "<Insert Section title>" [and as shown on Drawings].

Retain first subparagraph below if costs in addition to material costs are covered under this allowance. Revise to suit Project. Delete below if this allowance is for material costs only.

1. This allowance includes [material cost] [receiving, handling, and installation] [and] [Contractor overhead and profit].

Retain subparagraph below if this allowance is a quantity allowance with a corresponding unit price to be used to adjust the Contract Sum once final quantities are established. Revise to suit Project.

2. Coordinate quantity allowance adjustment with corresponding unit-price requirements in Section 01 22 00 "Unit Prices."

END OF SECTION 01 21 00
SECTION 01 22 00

UNIT PRICES

Revise this Section by deleting and inserting text to meet Project-specific requirements.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for unit prices.

B. Related Requirements:

   1. Section 01 21 00 “Allowances” for lump-sum and unit-cost allowances.
   2. Section 01 26 00 "Contract Modification Procedures“ for procedures for submitting and handling Change Orders.

1.3 DEFINITIONS

A. Unit price is an amount incorporated in the Agreement, applicable during the duration of the Work as a price per unit of measurement for materials, equipment, or services, or a portion of the Work, added to or deducted from the Contract Sum by Change Order, if the scope of Work or estimated quantities of Work required by the Contract Documents are increased or decreased.

1.4 PROCEDURES

A. Unit prices include all necessary material, plus cost for delivery, installation, insurance, applicable taxes, overhead, and profit.

B. Measurement and Payment: Upon completion of work involving unit prices, submit documentation to establish actual quantity of work provided. A Change Order will be issued in an amount equal to the actual quantity multiplied by the unit price.

C. University reserves the right to reject Contractor's measurement of work-in-place that involves use of established unit prices and to have this work measured, at University's expense, by an independent surveyor acceptable to Contractor.

D. List of Unit Prices: A schedule of unit prices is included in Part 3. Specification Sections referenced in the schedule contain requirements for materials described under each unit price.
PART 3 - EXECUTION

3.1 SCHEDULE OF UNIT PRICES

The sample schedule of unit prices in this article illustrates several types of common occurrences where unit prices allow indeterminate work elements to be bid under lump-sum contracts. Revise paragraphs below to suit Project.

Sample unit prices in "Unit Price 1" paragraph below illustrates one approach to applying unit prices to work that cannot be measured before bidding, but can be reasonably anticipated.

A. Unit Price 1: Removal of unsatisfactory soil and replacement with satisfactory soil material.
   1. Description: Unsatisfactory soil excavation and disposal off site and replacement with satisfactory fill material or engineered fill from off site, as required, according to Section 31 20 00 "Earth Moving."
   2. Unit of Measurement: Cubic yard of soil excavated, based on survey of volume removed.

"Quantity Allowance" Subparagraph below addresses relationship to quantity allowance. Retain below if coordination is required with a corresponding quantity allowance. Revise to suit Project.

   3. Quantity Allowance: Coordinate unit price with allowance adjustment requirements in Section 01 21 00 "Allowances."

Sample unit price in "Unit Price No. 2" Paragraph below illustrates a typical use of unit price in renovation work where work is being bid before extent of some work (in this case, underslab utilities) can be established in the Bidding Documents.

B. Unit Price No. 2: Cutting and patching of concrete floor slabs.
   1. Description: Cutting of new or existing concrete floor slabs up to <Insert dimension> thick, removal and excavation as required, and subsequent backfill, compaction, and patching of concrete according to Section 01 73 00 "Execution." not otherwise indicated in the Contract Documents.
   2. Unit of Measurement: Square feet of concrete removed.

Sample unit price in "Unit Price No. 3" Paragraph below illustrates use of unit price to establish pricing for items that may otherwise become contentious when priced as individual change order units.

C. Unit Price No. 3: Miscellaneous and structural steel.
   1. Description: Miscellaneous lintels and other supports not otherwise indicated in the Contract Documents, according to Section 05 12 00 "Structural Steel Framing" and Section 05 50 00 "Metal Fabrications."
   2. Unit of Measurement: Cost in place of pounds of fabricated steel as indicated on itemized invoice of steel supplier and verified by Architect/Engineer.

Copy and re-edit "Unit Price No. (Insert unit-price number)" Paragraph below for each unit price required for Project. See samples of unit-price descriptions in the Evaluations.

D. Unit Price No. <Insert unit-price number> - <Insert unit-price item>: 

UNIT PRICES
1. Description: \textit{Insert unit-price item description} according to Section \textit{<Insert Section number> "<Insert Section title>".}

2. Unit of Measurement: \textit{<Insert unit of measurement>}.  

\begin{quote}
\parbox{\textwidth}{
*Quantity Allowance* Subparagraph below addresses relationship to quantity allowance. Retain below if coordination is required with a corresponding quantity allowance. Revise to suit Project.
}
\end{quote}

3. Quantity Allowance: Coordinate unit price with allowance adjustment requirements in Section 01 21 00 "Allowances."

\textbf{END OF SECTION 01 22 00}
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for alternates.

1.3 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the bidding requirements that may be added to or deducted from the base bid amount if University decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1.  Alternates described in this Section are part of the Work only if enumerated in the Agreement.
2.  The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.
3.  Selection of alternates described in this Section may be deferred for possible selection at a subsequent date if so indicated in the Agreement.

1.4 PROCEDURES

A. Coordination: Revise or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1.  Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated revisions to alternates.

C. Execute accepted alternates under the same conditions as other work of the Contract.

D. Schedule: A schedule of alternates is included at the end of this Section. Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate.
1. Alternate descriptions are recognized as abbreviated and incomplete. Correlate the descriptions with applicable Specification Sections and Drawings for the provision of complete and coordinated work.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate No. <Insert number>: <Insert title of alternate>.

1. Base Bid: <Insert brief description of base-bid requirement> [as indicated on Sheet <Insert title of sheet>] [and] [as specified in Section <Insert Section number> "<Insert Section title>."]

2. Alternate: <Insert brief description of alternate requirement> [as indicated on Sheet <Insert title of sheet>] [and] [as specified in Section <Insert Section number> "<Insert Section title>."]

END OF SECTION 01 23 00
SECTION 01 25 00

SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for substitutions.

B. Related Requirements:

1. Section 01 21 00 "Allowances" for products selected under an allowance, if applicable.
2. Section 01 23 00 "Alternates" for products selected under an alternate, if applicable.
3. Section 01 60 00 "Product Requirements" for requirements for submitting comparable product submittals for products by listed manufacturers.

1.3 DEFINITIONS

A. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.

1. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
2. Substitutions for Convenience: Changes proposed by Contractor or University that are not required in order to meet other Project requirements but may offer advantage to Contractor or University.

1.4 ACTION SUBMITTALS

A. Substitution Requests: Submit each request for consideration in format and quantities specified in Section 01 33 00 “Submittal Procedures”. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.

1. Substitution Request Form: Use CSI Form 13.1A or Contractor-generated form with substantially the same information.
2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
   a. Statement indicating why specified product or fabrication or installation cannot be provided, if applicable.
b. Coordination information, including a list of changes or revisions needed to other parts of the Work and to construction performed by University and separate contractors that will be necessary to accommodate proposed substitution.

c. Detailed comparison of significant qualities of proposed substitution with those of the Work specified. Include annotated copy of applicable Specification Section. Significant qualities may include attributes such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.

d. Product Data, including drawings and descriptions of products and fabrication and installation procedures.

e. Samples, where applicable or requested.

f. Certificates and qualification data, where applicable or requested.

g. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners.

h. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.

i. Research reports evidencing compliance with building code in effect for Project, from ICC-ES.

j. Detailed comparison of Contractor's construction schedule using proposed substitution with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.

k. Cost information, including a proposal of change, if any, in the Contract Sum.

l. Contractor's certification that proposed substitution complies with requirements in the Contract Documents except as indicated in substitution request, is compatible with related materials, and is appropriate for applications indicated.

m. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

3. Architect/Engineer's Action: If necessary, Architect/Engineer in consultation with the University will request additional information or documentation for evaluation within seven calendar days of receipt of a request for substitution. Architect/Engineer in consultation with the University will notify Contractor of acceptance or rejection of proposed substitution within 14 calendar days of receipt of request, or seven calendar days of receipt of additional information or documentation, whichever is later.

   a. Forms of Acceptance: Change Order.

   b. Use product specified if Architect/Engineer does not issue a decision on use of a proposed substitution within time allocated.

1.5 QUALITY ASSURANCE

A. Compatibility of Substitutions: Investigate and document compatibility of proposed substitution with related products and materials. Engage a qualified testing agency to perform compatibility tests recommended by manufacturers.

1.6 PROCEDURES

A. Coordination: Revise or adjust affected work as necessary to integrate work of the approved substitutions.
PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

A. Substitutions for Cause: Submit requests for substitution immediately on discovery of need for change, but not later than 14 calendar days prior to time required for preparation and review of related submittals.

1. Conditions: Architect/Engineer in consultation with the University will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Architect/Engineer will return requests without action, except to record noncompliance with these requirements:

a. Requested substitution is consistent with the Contract Documents and will produce indicated results.
b. Requested substitution provides sustainable design characteristics that specified product provided.
c. Substitution request is fully documented and properly submitted.
d. Requested substitution will not adversely affect Contractor's construction schedule.
e. Requested substitution has received necessary approvals of authorities having jurisdiction.
f. Requested substitution is compatible with other portions of the Work.
g. Requested substitution has been coordinated with other portions of the Work.
h. Requested substitution provides specified warranty.
i. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

B. Substitutions for Convenience: Not allowed.

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 25 00
SECTION 01 26 00
CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for handling and processing Contract modifications.

B. Related Requirements:

1. Section 01 25 00 "Substitution Procedures" for administrative procedures for handling requests for substitutions made after the Contract award.

Retain one of the three options in the subparagraph below based on project delivery method: Design/Bid/Build, CMGC, or Design/Build.

2. [Contractor's Agreement Design/Bid/Build, State Form SC-6.21 and The General Conditions of the Construction Contract Design/Bid/Build, State Form SC-6.23] [Construction Manager/General Contractor Agreement CMGC, State Form SC-6.4] [Design/Build Agreement, State Form SC-8.0 and The General Conditions of the Design/Build Agreement, State Form SC-8.1] for definitions and contractual requirements related to contract modification procedures.

1.3 DEFINITIONS

A. Change Order: A written order in compliance with the requirements of the Contract authorizing changes in the Work. For the purposes of this Section a Change Order and a Contract Amendment shall have the same meaning.

1.4 INFORMATIONAL SUBMITTALS

A. Contractor's Authorized Signatory: Submit name of individual authorized to accept changes and responsible for informing others employed by Contractor of changes in the Work.

1.5 MINOR CHANGES IN THE WORK

A. Architect/Engineer will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or the Contract Time.
1.6 CHANGE ORDER BULLETIN

A. University-Initiated Change Order Bulletin: Architect/Engineer will issue a detailed description of proposed changes in the Work that may require adjustment to the Contract Sum or the Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications. It will also state the time period for which the request will remain valid.

2. Work Change Order Bulletins issued by Architect/Engineer are not instructions either to stop work in progress or to execute the proposed change.

B. Contractor-Initiated Change Order Bulletin: If latent or changed conditions require modifications to the Contract, Contractor may initiate a request for a change to Architect/Engineer.

2. Include a statement outlining reasons for the change and the effect of the change on the Work. Provide a complete description of the proposed change. Indicate the effect of the proposed change on the Contract Sum and the Contract Time.

1.7 CHANGE ORDER PROPOSAL

A. Change Order Proposal: In response to a University-Initiated Change Order Bulletin or accompanying a Contractor-Initiated Change Order Bulletin, submit a quotation estimating cost adjustments to the Contract Sum and the Contract Time necessary to execute the change described.

2. Labor Rates: Prior to submitting first Change Order Proposal, submit bare, unburdened hourly labor rates for all contractor and subcontractor labor categories; submit itemized breakdown of all applicable additional labor benefit costs to be added to the bare labor cost to arrive at the total burdened hourly labor cost.
3. Equipment Costs: Provide cost backup for all equipment clearly indicating equipment billing rates and sufficient to demonstrate, as determined by the University Project Manager, that proposed rates are competitive and reasonable in all cases. Submit completed Change Order Proposal Form within the requested timeframe. Include backup documentation to support calculations consistent with Contract provisions, including but not limited to, the following:

a. Contractor and Subcontractor labor, material and equipment costs including:

1) A list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.
2) Applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
3) Costs of labor and supervision directly attributable to the change and as permitted by the terms and conditions of the General Contract for Construction.

b. Contractor and Subcontractor overhead and profit.

c. Contractor’s bond cost.

d. Justification for Change in Contract Time: An updated Contractor’s construction schedule that indicates the effect of the change, including, but not limited to, changes in activity
duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.

4. Maintain detailed records of work completed. Provide complete information for evaluation of proposed changes and to substantiate proposed changes in Contract Sum or Contract Time.

1.8 ADMINISTRATIVE CHANGE ORDERS

A. Allowance Adjustment: See Section 01 21 00 "Allowances" for administrative procedures for preparation of Change Order Proposal for adjusting the Contract Sum to reflect actual costs of allowances.

B. Unit-Price Adjustment: See Section 01 22 00 "Unit Prices" for administrative procedures for preparation of Change Order Proposal for adjusting the Contract Sum to reflect measured scope of unit-price work.

1.9 CHANGE ORDER PROCEDURES

A. Submit three signed copies of Change Order Proposal to Architect/Engineer for review.

1. University-Initiated Change Order Bulletins: University and Architect/Engineer will evaluate Contractor’s Change Order Proposal and either request additional information or suggest modifications. Based on this review and evaluation University will either accept or reject the proposal.

2. Contractor-Initiated Change Order Bulletins: Architect/Engineer will evaluate Contractor’s claim based on the terms and conditions of the Contractor Agreement and General Conditions of the Construction Contract, as applicable.

3. Architect/Engineer’s Action: When satisfied as to the accuracy and completeness of the Change Order Proposal, the Architect/Engineer will sign all three copies and forward to the University for consideration.

B. On University's approval of a Change Order Proposal, Architect/Engineer will prepare, sign and forward three copies of a Change Order, State Form SC-6.31 available from the website of the Office of the State Architect, for signature by the Contractor. Contractor then forwards all three copies of signed Change Order to the University for signature and distribution of fully executed copies to Architect/Engineer and Contractor for record.

C. Upon receipt of a fully executed Change Order, promptly perform the following:

1. Revise Schedule of Values on the Application for Payment Form by indicating each authorized Change Order as a separate line item and adjusting the Contract Sum as shown on the Change Order.

   a. University will not pay for changes to the Work until authorized by a Change Order signed by all parties.

2. Revise the Progress Schedule to reflect any change in the Contract Time.

3. Enter changes in the Project Record Documents.
PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 26 00
SECTION 01 29 00
PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment.
B. Related Requirements:
   1. Section 01 21 00 "Allowances" for procedural requirements governing the handling and processing of allowances.
   2. Section 01 22 00 "Unit Prices" for administrative requirements governing the use of unit prices.
   3. Section 01 26 00 "Contract Modification Procedures" for administrative procedures for handling changes to the Contract.
   4. Section 01 32 00 "Construction Progress Documentation" for administrative requirements governing the preparation and submittal of the Contractor's construction schedule.
   5. For projects required to obtain LEED certification, Division 01 Section "Sustainable Design Requirements" for administrative requirements governing submittal of cost breakdown information required for LEED documentation.

1.3 DEFINITIONS
A. Schedule of Values: A statement furnished by Contractor allocating portions of the Contract Sum to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

1.4 SCHEDULE OF VALUES
A. Coordination: Coordinate preparation of the schedule of values with preparation of Contractor's construction schedule. Schedule of values report from cost-loaded Critical Path Method Schedule prepared in accordance with Section 01 32 00 “Construction Progress Documentation” may serve to satisfy requirements for the schedule of values.

   1. Coordinate line items in the schedule of values with other required administrative forms and schedules, including the following:

      a. Application for Payment forms with continuation sheets.
      b. Submittal schedule.
      c. Items required to be indicated as separate activities in Contractor's construction schedule.

         1) Construction Manager’s Fee.
2) Estimated Project General Conditions Costs.

2. Submit schedule of values and hold a conference with the Architect/Engineer and University Project Manager to finalize the schedule of values at earliest possible date, but no later than 10 business days before the date scheduled for submittal of initial Certificates and Applications for Payment.

---

Retain "Subschedules for Separate Elements of Work" Subparagraph below if the Work is divided into separate elements intended for partial occupancy prior to Project Completion.

3. Subschedules for Separate Elements of Work: Where the Contractor's construction schedule defines separate elements of the Work, provide subschedules showing values coordinated with each element.

B. Format and Content: Use Project Manual table of contents as a guide to establish line items for the schedule of values. Provide at least one line item for each Specification Section.

1. Identification: Include the following Project identification on the schedule of values:

   a. Project name and location.
   b. Name of Architect/Engineer.
   c. Architect/Engineer's project number.
   d. Contractor's name and address.
   e. Date of submittal.

Retain first subparagraph below for Small Projects and second subparagraph below for Large Projects.

2. Arrange schedule of values consistent with format of AIA Document G703.

3. Arrange the schedule of values in tabular form with separate columns to indicate the following for each item listed:

   a. Related Specification Section or Division.
   b. Description of the Work.
   c. Name of subcontractor.
   d. Name of manufacturer or fabricator.
   e. Name of supplier.
   f. Change Orders (numbers) that affect value.
   g. Dollar value of the following, as a percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.

       1) Labor.
       2) Materials.
       3) Equipment.


   a. Include separate line items under Contractor and principal subcontracts for LEED documentation, where applicable, and other Project closeout requirements in an amount totaling five percent of the Contract Sum and subcontract amount.

5. Round amounts to nearest whole dollar; total shall equal the Contract Sum.
6. Provide a separate line item in the schedule of values for each part of the Work where Applications for Payment may include materials or equipment purchased or fabricated and stored, but not yet installed.
   a. Differentiate between items stored on-site and items stored off-site. If required, include evidence of insurance.
7. Each item in the schedule of values and Applications for Payment shall be complete. Include total cost and proportionate share of general overhead and profit for each item.
   a. Temporary facilities and other major cost items that are not a direct cost of actual work-in-place shall be shown as separate line items in the schedule of values.
8. Schedule Updating: Update and resubmit the schedule of values before the next Applications for Payment when Change Orders result in a change in the Contract Sum.

1.5 APPLICATIONS FOR PAYMENT

A. Each Application for Payment following the initial Application for Payment shall be consistent with previous applications and payments as certified by Architect/Engineer and paid for by University.
1. Initial Application for Payment, Application for Payment at time of Substantial Completion, and final Application for Payment involve additional requirements.

B. Pay Application and Schedule Review Meetings: Conduct in accordance with Section 01 31 00 “Project Management and Coordination.” Provide draft application for payment and draft schedule update reflecting work accomplished during previous pay period. Review progress achieved; discuss and resolve issues affecting the progress; and review critical activities to be accomplished during the following 90 calendar days.
1. Jobsite Walk: When required, conduct a walk of the jobsite to confirm progress related to any activity in question.

C. Monthly Schedule Reporting: Upon conclusion of the Pay Application and Schedule Review Meeting, but not later than the 28th of the month, update the Construction Schedule and submit the Pay Application.

D. Payment Application Times: Submit Application for Payment to Architect/Engineer by the first day of the month and no more than five (5) business days prior thereto. The period covered by each Application for Payment is per the date indicated in the Application.

E. Payment Application Review: The Architect/Engineer shall, within five (5) business days after the receipt of each Certificate and Application for Payment, review the Project Application for Payment and either execute a Project Certificate for Payment to the University or notify the Contractor in writing of the reasons for withholding a Certificate.
1. All applications for payment, except the final application, and the payments there under, shall be subject to correction in the next application rendered following the discovery of any error

F. Application for Payment Forms: Use State Form SBP-7.2 “Certification for Contractor Payment.”

G. Application Preparation: Complete every entry on form. Notarize and execute by a person authorized to sign legal documents on behalf of Contractor. Architect/Engineer will return incomplete applications without action.
PAYMENT PROCEDURES

1. Entries shall match data on the schedule of values and Contractor's construction schedule. Use updated schedules if revisions were made.

2. Include amounts for work completed following previous Application for Payment, whether or not payment has been received. Include only amounts for work completed at time of Application for Payment.

3. Include amounts of Change Orders issued before last day of construction period covered by application.

4. Indicate separate amounts for work being carried out under University-requested project acceleration.

H. Stored Materials: Include in Application for Payment amounts applied for materials or equipment purchased or fabricated and stored, but not yet installed. Differentiate between items stored on-site as approved in advance by the University Project Manager and items stored at an off-site location previously agreed upon in writing.

1. Provide certificate of insurance, evidence of transfer of title to University, and consent of surety to payment, for stored materials.

2. Provide supporting documentation that verifies amount requested, such as paid invoices. Match amount requested with amounts indicated on documentation; do not include overhead and profit on stored materials.

3. Provide summary documentation for stored materials indicating the following:

   a. Value of materials previously stored and remaining stored as of date of previous Applications for Payment.

   b. Value of previously stored materials put in place after date of previous Application for Payment and on or before date of current Application for Payment.

   c. Value of materials stored since date of previous Application for Payment and remaining stored as of date of current Application for Payment.

I. Transmittal: Submit three signed and notarized original copies of each Application for Payment to Architect/Engineer by a method ensuring receipt. One copy shall include waivers of lien and similar attachments if required.

1. Transmit each copy with a transmittal form listing attachments and recording appropriate information about application.

J. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:

1. List of subcontractors.

2. Schedule of values.

3. For projects required to obtain LEED certification, LEED submittal for project materials cost data.

4. Contractor's construction schedule (preliminary if not final).

5. Products list (preliminary if not final).

6. For projects required to obtain LEED certification, LEED action plans.

7. Schedule of unit prices.

8. Submittal schedule (preliminary if not final).

9. List of Contractor's staff assignments.

10. List of Contractor's principal consultants.


13. Initial progress report.

K. Application for Payment at Substantial Completion: After Architect/Engineer issues the Certificate of Substantial Completion, submit an Application for Payment showing 100 percent completion for portion of the Work claimed as substantially complete.

1. Include documentation supporting claim that the Work is substantially complete and a statement showing an accounting of changes to the Contract Sum.
2. This application shall reflect Certificate(s) of Substantial Completion issued previously for University occupancy of designated portions of the Work.

L. Final Payment Application: After completing Project closeout requirements, submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited to the following:

1. All items on Pre-acceptance Checklist (State Form SBP-05) have been completed.
2. Notice of Acceptance (State Form SBP-6.27) has been issued.
3. Statements to support local sales tax refunds, if any submitted.
4. Notice of Contractor’s settlement has been published.
5. Evidence of completion of Project closeout requirements, including but not limited to:
   a. Submittal of Record Documents.
   b. Submittal of all Operation and Maintenance Manuals.
   c. Completion of all required demonstration and training.
6. Updated final statement, accounting for final changes to the Contract Sum.
7. Evidence that claims have been settled.
8. Final meter readings for utilities, a measured record of stored fuel, and similar data as of date of Substantial Completion or when University took possession of and assumed responsibility for corresponding elements of the Work.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 29 00
SECTION 01 31 00
PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:
   1. General coordination procedures.
   2. Coordination drawings.
   3. Requests for Information (RFIs).
   4. Project Web site.
   5. Project meetings.

B. Related Requirements:
   1. Section 01 32 00 "Construction Progress Documentation" for preparing and submitting Contractor's construction schedule.
   2. Section 01 73 00 "Execution" for procedures for coordinating general installation and field-engineering services, including establishment of benchmarks and control points.
   3. Section 01 77 00 "Closeout Procedures" for coordinating closeout of the Contract.

1.3 DEFINITIONS
A. RFI: Request from Contractor seeking information required by or clarifications of the Contract Documents.

1.4 INFORMATIONAL SUBMITTALS
A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Within 21 calendar days of Notice of Award submit, as complete as possible, a preliminary list to include all major subcontractors. Augment, complete and submit the final subcontractor list within 60 calendar days of Notice of Award, unless a longer duration is approved by the Architect/Engineer. Include the following information in tabular form:
   1. Name, address, and telephone number of entity performing subcontract or supplying products.
   2. Number and title of related Specification Section(s) covered by subcontract.
   3. Drawing number and detail references, as appropriate, covered by subcontract.
B. Key Personnel Names: Within 14 calendar days after Notice to Proceed, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home, office, and cellular telephone numbers and e-mail addresses. Provide names, addresses, and telephone numbers of individuals assigned as alternates in the absence of individuals assigned to Project.

Retain option in subparagraph below for Large Projects administered through a Project Web site specified later in this Section.

1. Post copies of list in project meeting room, in temporary field office, [on Project Web site] and by each temporary telephone. Keep list current at all times.

1.5 GENERAL COORDINATION PROCEDURES

A. General: Each entity involved in the performance of work for the entire Project shall cooperate in the overall coordination of the Work; promptly, when requested, furnish information concerning its portion of the Work; and respond promptly and reasonably to the decisions and requests of persons designated with coordination, supervision, administrative or similar authority.

1. University Standard Project Management Forms
   a. Where applicable, obtain from the University Project Manager and use the following University Standard Forms:

   1) Preconstruction Agenda
   2) Change Order Log with Contingency Codes
   3) Access Control Badge Application Form
   4) Utility Interruption Request Form
   5) Utility Start-Up Request Form
   6) Fire Alarm/Sprinkler Disable Request Form
   7) Hot Work Permit Form
   8) Anschutz Medical Campus (AMC) Street and Parking Lot Closure Form
   9) Indoor Air Quality (IAQ) Planning Checklist
   10) Indoor Air Quality (IAQ) Inspection Checklist

2. Site Utilization:
   a. In addition to the site utilization limitations and requirements indicated in Section 01 10 00 “Summary” and indicated by the Contract Documents; administer the allocation of available space equitably among entities needing access and space, so as to produce the best overall efficiency in the performance of the total work of the project. Schedule deliveries so as to minimize the space and time requirements for storage of materials and equipment on the site; but do not unduly risk delays in the work.

   b. Concurrent with work of the Contractor, other contractors, suppliers, and the University personnel may be working in relatively close proximity. The Contractor is solely responsible for coordinating their work with that of other contractors and will make no claims for failure to do so.

3. Layout:
   a. It is recognized that the Contract Documents are diagrammatic in showing certain physical relationships of the various elements and systems and their interfacing with other elements and systems. Establishment and coordination of these relationships is the exclusive responsibility of the Contractor. Do not scale the drawings. Lay out and arrange all elements to contribute to safety, efficiency and to carry the harmony of design throughout
the Work. In case of conflict or undimensioned locations, verify required positioning with Architect/Engineer.

4. Substrate Examination:
   a. The Installer of each element of the work must examine the conditions of the substrate to receive the work, dimensions and spaces adjacent, tolerances, interfacing with other elements and services, and the conditions under which the work will be performed, and must notify the Contractor in writing of conditions detrimental to the proper or timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

5. Large and Heavy Equipment:
   a. Contractor to coordinate with University Project Manager requirements to be maintained for the subsequent entry of large equipment units. Coordinate the movement of heavy items with shoring and bracing, so that the building structure will not be overloaded during the movement and installation.
   b. Where equipment or products to be installed on the roof are too heavy to be hand-carried, do not transport across roof deck; position by crane or other device so as to avoid overloading the roof deck.

B. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections of the Specification that depend on each other for proper installation, connection, and operation.

   1. Contractor Communication with the University: Direct all communication with the University through the University Project Manager.
   2. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
   3. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
   4. Make adequate provisions to accommodate items scheduled for later installation.

C. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

   1. Prepare similar memoranda for University and separate contractors if coordination of their Work is required.

D. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

   1. Preparation of Contractor's construction schedule.
   2. Preparation of the schedule of values.
   3. Installation and removal of temporary facilities and controls.
   4. Delivery and processing of submittals.
   5. Progress meetings.
   6. Preinstallation conferences.
   7. Project closeout activities.
   8. Startup and adjustment of systems.
E. Coordination Of Submittals: Prior to transmittal to the Architect/Engineer, review shop and erection drawings, product data, and samples for compliance with Contract Documents and for coordination among work of all Sections of the Specifications. Coordination of submittals shall include, but not be limited to the following:

1. Verification of field dimensions and clearances and relationship to available space and anchors.
2. Verification of compatibility with equipment and work of other Sections, electrical characteristics, and operational control requirements.
3. Verification of motor voltages and control characteristics.
4. Coordination of controls, interlocks, wiring of pneumatic switches, and relays.
5. Coordination of wiring and control diagrams.
6. Review of the effect of any changes on work of other Sections.
7. For any item to be installed in or on a finished surface, certify that applicable Contract Documents have been checked and that the item submitted is compatible with the surface finish on which it is to be installed.
8. Equipment and material submittals shall show sufficient data to indicate complete compliance with Contract Documents as follows:
   a. Proper sizes and capabilities.
   b. Ability to fit in the available space in a manner that will allow proper service.
   c. Construction methods, materials, and finishes.
   d. List of accessories.

F. Special Coordination Requirements for Mechanical and Electrical Work:

1. General: Provide necessary work and services required to coordinate the complete installation of heating, ventilating, and air conditioning (HVAC) equipment and systems; plumbing systems and fixtures; electrical equipment, fixtures, and systems; and other equipment or systems containing motors and controls or requiring connection to mechanical or electrical systems; all so that the various systems perform as indicated and are in harmony with other project Work.
2. Contract Drawings:
   a. Drawings are schematic in nature, and indicate in general how the various components are integrated with other parts of the building. Coordinate exact locations by job measurement, by verifying the requirements of other trades, and by review of Contract Documents.
3. Mechanical and Electrical Drawings indicate general routing of the various parts of the systems, but do not indicate all sizes, fittings, offsets, and runouts which are required. Coordinate correct sizes, fittings, offsets, and runouts required to fit systems into allocated spaces. Coordinate locations of all light fixtures, vents, and supply grilles to conform to the ceiling grid system or other modular finishes.
4. Coordinate installation of mechanical and electrical work in compliance with the following requirements:
   a. Install piping, ductwork and similar services straight and true, aligned with other work, close to walls and overhead structure, allowing for insulation, concealed (except where indicated as exposed) in occupied spaces, and out-of-the-way with maximum passageway and headroom remaining in each space.
   b. Install electrical work in a neat, organized manner with conduit and similar services in or parallel with building lines, and concealed unless indicated as exposed.
   c. For all work maintain maximum practical overhead clearance but not less than 6" above ceiling. Where exposed, maintain 7'-0" minimum clearance.
   d. Arrange all work to facilitate maintenance and repair or replacement of equipment. Locate services requiring maintenance on valves and similar units in front of services requiring less maintenance. Connect equipment for ease of disconnecting, with minimum of interference with other work.
e. Provide space to permit removal of coils, tubes, fan shafts, filters, other parts which may require replacement.

f. Locate operating and control equipment and devices for easy access. Furnish access panels where units are concealed by finishes and similar work.

g. Integrate mechanical work in ceiling plenums with suspension system, light fixtures and other work, so that required performances of each will be achieved.

h. Give the right-of-way to piping systems required to slope for drainage over other service lines and ductwork.

i. Advise other trades of openings required in their work for accommodation of mechanical and electrical elements. Provide and place sleeves and anchors required in other work.

5. Access to Equipment: Except where located above accessible ceilings, provide access panels wherever access is required to concealed valves, controls, dampers, pull boxes and other devices requiring ongoing or periodic access.

   a. Acceptable types of access panels are specified in Division 08.

   b. Each trade is responsible for providing access panels needed for access to their equipment and coordinating installation with other Division 03, 04, 06 and 09 trades.

   c. Coordinate requirements and obtain approval of locations from Architect/Engineer.

G. Compatibility of Systems:

1. Provide products and equipment which are compatible with other work requiring mechanical/electrical interface including electrical connections, control devices, water, drain and other piping connections. Verify electrical characteristics, fuel requirements and other interface requirements before ordering equipment and resolve conflicts that may arise.

2. Coordinate equipment, mechanical and electrical work in accordance with the following schedule:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>FURNISHED BY</th>
<th>MOUNTED BY</th>
<th>LOW VOLTAGE WIRED BY</th>
<th>POWER WIRED &amp; CONNECTED BY</th>
<th>LOW VOLTAGE CONTROL CONNECTED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment motors</td>
<td>I</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>--</td>
</tr>
<tr>
<td>Motor starters, contactors and overload heaters</td>
<td>MI</td>
<td>EI</td>
<td>EI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Fused and unfused disconnect switches</td>
<td>EI**</td>
<td>EI**</td>
<td>EI**</td>
<td>EI</td>
<td>--</td>
</tr>
<tr>
<td>Manual operating switches, speed switches, push-button stations and pilot lights</td>
<td>MI</td>
<td>EI</td>
<td>EI</td>
<td>EI</td>
<td>EI</td>
</tr>
<tr>
<td>Duct detectors</td>
<td>EI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Control relays and transformers</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Thermostats, time switches*</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Temperature control panels</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Motor and solenoid valves, damper motors, PE and EP</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>--</td>
<td>MI</td>
</tr>
<tr>
<td>switches</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Refrigeration equipment, cooling tower and controls</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Electric meters</td>
<td>EI</td>
<td>EI</td>
<td>EI</td>
<td>EI</td>
<td>MI</td>
</tr>
<tr>
<td>Steam meters</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
</tr>
<tr>
<td>Chilled water meters,</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
</tr>
<tr>
<td>Water meters</td>
<td>MI***</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
<td>MI</td>
</tr>
</tbody>
</table>

I = Installer of equipment requiring electrical service  
EI = Electrical Installer  
MI = Mechanical Installer

* Motor driven units which are controlled from line voltage automatic controls such as line voltage thermostats, float switches or time switches which conduct full load current of the motor shall be wired for both power and control circuit under the electrical contract. However, if the control device does not conduct full load current, then the responsibility shall be that set forth in the above schedule. (Example: a 208 volt, 3-phase, 3- wire motor requires 120 volt control. Electrical Installer shall furnish a 120 volt circuit for control and 208 volt circuit for power and wire the power circuit. Mechanical Installer shall wire the control circuit.)

** Disconnects for AH units are factory mounted.

***Building Service meter provided by Civil. Any sub meter provided by MI. Coordinate meter requirements with utility for remote monitoring by 23 09 00 – Instrumentation and Controls.

H. Special Coordination Requirements for Exterior Envelope Work:

1. General: Provide necessary work and services required to coordinate the complete and continuous installation of the building’s heat, air and moisture barriers. Exterior building envelope construction to be coordinated includes, but is not limited to, below-grade walls, slabs-on-grade, exterior opaque walls, windows, curtain walls, roofs, and skylights.

2. Contract Drawings:
   a. Drawings indicate general concepts and design intent for continuity of heat, air and moisture barriers at each exterior building envelope component and at transitions between building envelope components. Coordinate details for continuity based on actual product selections and Contractor’s proposed sequence of construction.

I. Complete Systems:

1. It is the intent of the Contract Documents that all systems, including mechanical and electrical, be complete and functional to provide the intended or specified performance. Provide all incidental items and parts necessary to achieve this requirement.

2. Provide correctly sized power, utilities, piping, drains, services and their connections to equipment and systems requiring them, whether or not specific items are listed in the schedule under “Compatibility of Systems” paragraph in this Section.

J. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.
1. Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work. See other Sections for disposition of salvaged materials that are designated as University's property.

2. Establish recycling program at job site. Refer to Section 01 74 19 “Construction Waste Management and Disposal” for additional requirements.

1.6 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.

b. Coordinate the addition of trade-specific information to the coordination drawings by multiple subcontractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.

c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.

d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.

e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.

f. Indicate required installation sequences.

g. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect/Engineer indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

Retain “Coordination Drawing Organization” Paragraph below and delete subsequent “Coordination Digital Data Files” Paragraph for Small Projects not utilizing a Building Information Model to facilitate coordination of systems.

B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical Work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings, where required, to adequately represent the Work.

2. Plenum Space: Indicate subframing for support of ceiling and wall systems, mechanical and electrical equipment, and related Work. Locate components within ceiling plenum to accommodate layout of light fixtures indicated on Drawings. Indicate areas of conflict between light fixtures and other components.

3. Mechanical Rooms: Provide coordination drawings for mechanical rooms showing plans and elevations of mechanical, plumbing, fire-protection, fire-alarm, and electrical equipment.

4. Structural Penetrations: Indicate penetrations and openings required for all disciplines.
5. Slab Edge and Embedded Items: Indicate slab edge locations and sizes and locations of embedded items for metal fabrications, sleeves, anchor bolts, bearing plates, angles, door floor closers, slab depressions for floor finishes, curbs and housekeeping pads, and similar items.

6. Mechanical and Plumbing Work: Show the following:
   a. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
   b. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.
   c. Fire-rated enclosures around ductwork.

7. Electrical Work: Show the following:
   a. Runs of vertical and horizontal conduit 1-1/4 inches in diameter and larger.
   b. Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
   c. Panel board, switch board, switchgear, transformer, busway, generator, and motor control center locations.
   d. Location of pull boxes and junction boxes, dimensioned from column center lines.

8. Fire-Protection System: Show the following:
   a. Locations of standpipes, mains piping, branch lines, pipe drops, and sprinkler heads.

9. Windows, Curtain Wall, and Exterior Wall Assembly Transition Work: Show all components of each adjacent wall or window system and all required compatible tie-ins between them including transition strips, flashings and sealants. Clearly identify each product, its configuration and its extent. Shop Drawings which only generically indicate adjacent construction and/or indicate “construction by others” will not be acceptable.

10. Review: Architect/Engineer will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Architect/Engineer determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Architect/Engineer will so inform Contractor, who shall make changes as directed and resubmit.

11. Coordination Drawing Prints: Prepare coordination drawing prints according to requirements in Section 01 33 00 "Submittal Procedures."

C. Virtual Design and Construction (VDC), Building Information Model (BIM) and Coordination Digital Data Files:

1. General: It is expected that, to the greatest extent applicable, Contractor will employ VDC and BIM tools to facilitate the construction, coordination, scheduling and phasing of the Work.
2. Contractor’s VDC implementation shall include at a minimum the following activities:
   a. Development and maintenance of a three-dimensional building information model (BIM) of the Work that includes contractor-developed, shop-drawing level information of the following building components and systems:
      1) Building structure, including but not limited to, foundations, columns, beams, joists, purlins, floor and roof decking and fill, bracing, and load-bearing walls.
2) HVAC systems, including but not limited to, HVAC piping and pumps, air distribution ductwork, fans, air terminal units, air outlets and inlets; central cooling equipment compressors, chillers, condensers, and cooling towers; boilers, heat exchangers and packaged and/or custom air-handling units and thermal storage systems.

3) Plumbing systems, including but not limited to, water distribution, storm drainage and sanitary sewerage waste and vent piping, water-heaters and plumbing fixtures.

4) Fire suppression systems, including but not limited to, standpipes, sprinkler systems, fire pumps, and non-water-based fire-extinguishing systems.

5) Electrical systems, including but not limited to, conduit greater than 1-1/2 inches in diameter, or bundled conduits, cable-tray, transformers, switchgear, switchboards, panelboards, generators, lightning protection and lighting.

6) Communication systems, including but not limited to, structured cabling, premise wiring distribution system, equipment room fittings, racks, frames and enclosures, data communications switches, hubs, and routers, common use systems, and paging systems.

7) Vertical Transportation systems including.

8) Architectural building systems including interior and exterior walls, windows, curtain walls, ceilings, and roof.

b. Collision Detection Reports: Based on information developed and included in the Contractor’s three-dimensional BIM, perform collision/interference checking and develop reports for review and resolution by the integrated Contractor team, including subcontractors, manufacturers and suppliers, working with the Design team where needed prior to release of fabrication drawings.

3. Schedule Visualization: Develop and maintain a three-dimension building information model for the expressed purpose of visually demonstrating and communicating proposed project construction schedule and phasing to University, subcontractors and suppliers as applicable. Include all major building systems and construct in such a fashion as to permit animation showing sequential construction of the project based on and driven by the approved Primavera construction schedule.

4. Prepare coordination digital data files according to the following requirements:

a. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.

b. File Submittal Format: Submit or post coordination drawing files using format same as file preparation format and Portable Data File (PDF) format.

c. BIM File Incorporation: Develop and incorporate coordination drawing files into Building Information Model established for Project.

1) Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Architect/Engineer.

d. Architect/Engineer will furnish Contractor one set of digital data files of Drawings for use in preparing coordination digital data files.

1) Architect/Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to Drawings.
2) Digital Data Software Program: Drawings are available in <Insert name and version of digital data software program and operating system>.

3) Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to University and Architect/Engineer.

5. Review: At request of Contractor and at Architect/Engineer’s discretion, Architect/Engineer will participate in BIM coordination and review meetings and will review coordination model and drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are the Contractor's responsibility. If the Architect/Engineer determines that the coordination model and drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, the Architect/Engineer will inform the Contractor, who shall make changes as directed and resubmit.

D. Interference Resolution: Whenever job measurements and an analysis of the building coordination model, Drawings and Specifications indicate that the various systems cannot be installed without significant deviation from the intent of the Contract, prepare interference drawings as required to indicate conflict between the various systems and other components of the building such as beams, columns, and walls. Include plans, elevations, sections, and other details drawn to large scale as required to clearly define the interference and to indicate the Contractor's proposed solution. Submit interference drawings for review by the Architect prior to proceeding with work in the general areas of the conflict.

1.7 REQUESTS FOR INFORMATION (RFIs)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Architect/Engineer will return RFIs submitted to Architect/Engineer by other entities controlled by Contractor with no response.
2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect/Engineer.
6. RFI number, numbered sequentially.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. RFI Forms: Hard copy form or software-generated form with substantially the same content as indicated above, acceptable to Architect/Engineer.

1. Attachments shall be electronic files in Adobe Acrobat PDF format.

D. Architect/Engineer's Action: Architect/Engineer will review each RFI, determine action required, and respond. Allow seven calendar days for Architect/Engineer's response for each RFI. RFIs received by Architect/Engineer after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:
   a. Requests for approval of submittals.
   b. Requests for approval of substitutions.
   c. Requests for approval of Contractor's means and methods.
   d. Requests for coordination information already indicated in the Contract Documents.
   e. Requests for adjustments in the Contract Time or the Contract Sum.
   f. Requests for interpretation of Architect/Engineer's actions on submittals.
   g. Incomplete RFIs or inaccurately prepared RFIs.

2. Architect/Engineer's action may include a request for additional information, in which case Architect/Engineer's time for response will date from time of receipt of additional information.

3. Architect/Engineer's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Contractor-Initiated Change Order Bulletin and Proposal according to Section 01 26 00 "Contract Modification Procedures."

   a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect/Engineer in writing within seven calendar days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by RFI number. Submit log weekly. [Use CSI Log Form 13.2B or Contractor-generated form of substantially same content.] [Use software log that is part of Project Web site.] Include the following:

1. Project name.
2. Name and address of Contractor.
3. Name and address of Architect/Engineer.
4. RFI number including RFIs that were returned without action or withdrawn.
5. RFI description.
6. Date the RFI was submitted.
7. Date Architect/Engineer's response was received.

F. On receipt of Architect/Engineer's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect/Engineer within seven calendar days if Contractor disagrees with response.

1.8 PROJECT WEB SITE

Retain this article for Large Projects. Note that Construction Manager/General Contractor Agreement CMGC (State Form SC-6.4) requires the CMGC to provide and use Project Management Software for project control, communication and documentation.
A. Provide, administer, and use Project Web site for purposes of hosting and managing project communication and documentation until Final Completion. Project Web site shall include the following functions:

1. Project directory.
2. Project correspondence.
3. Meeting minutes.
5. RFI forms and logs.
7. Electronic submittal document hosting, viewing and transmitting.
8. Drawing and specification document hosting, viewing, and updating.
10. Change orders.
11. Daily reports.
12. Punchlists.

B. Provide up to twenty-five (25) Project Web site user licenses for use of the University, Architect/Engineer, and Architect/Engineer's consultants. Provide eight hours of software training at Project Site office for Project Web site users.

C. On completion of Project, provide one each complete archive copy of Project Web site files to University and to Architect/Engineer in a digital storage format acceptable to Architect/Engineer.

D. Software:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Meridian Systems; Prolog or ProjectTalk under their current published licensing agreements. Comparable software by other software suppliers may be provided if approved in writing at the sole discretion of the Architect/Engineer in consultation with the University Project Manager.

E. Contractor, subcontractors, and other parties granted access by Contractor to Project Web site shall execute a data licensing agreement in the form of Agreement acceptable to University and Architect/Engineer.

1.9 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify University and Architect/Engineer of scheduled meeting dates and times a minimum of 4 business days prior to meeting.
   a. Participants, including representatives of subcontractors and suppliers, shall be qualified, familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
3. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including University and Architect/Engineer, within three business days of the meeting.
B. Preconstruction Conference: Schedule and conduct a preconstruction conference before starting construction, at a time and site convenient to all parties, but not later than 14 calendar days after Notice to Proceed.

1. Conduct the conference to review responsibilities and personnel assignments.
2. Attendees: Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work and include the following:
   a. Authorized representatives of University:
      1) University Project Manager.
      2) University Building Maintenance Operations (BMO) Representative.
   b. Architect/Engineer and their consultants.
   c. Contractor’s project manager and superintendent.
   d. Major subcontractors and suppliers.
   e. Other concerned parties shall attend the conference.

3. Agenda: Discuss items of significance that could affect progress, including the following:
   a. Designation of key personnel and their duties.
   b. Lines of communications.
   c. List of major subcontractors and suppliers.
   d. Tentative construction schedule.
      1) Phasing.
      2) Critical work sequencing and long-lead items.
      3) Equipment deliveries and priorities.
   e. Procedures and processing of:
      2) RFI’s.
      3) Testing and inspecting.
      4) Applications for Payment.
      5) Submittals.
      6) Preparation of record documents.
   f. Use of the premises, existing building and adjacent buildings as applicable.
      1) Work restrictions.
      2) Working hours.
      3) University's occupancy requirements.
      4) Procedures for disruptions and shutdowns.
      5) Construction parking and staging.
      6) Construction route and site access.
      7) Office, work, and storage areas.
      8) Progress cleaning and housekeeping procedures.
   g. Project coordination.
   h. Distribution of the Contract Documents.
   i. Temporary facilities and controls.
   j. Indoor Air Quality Plan and Monitoring including procedures for moisture and mold control.
   k. Construction waste management and recycling.
I. Safety.

1) Fire and Life Safety.
2) Health and Safety.

m. First aid.

n. Security.
o. Building Department.
p. Telecommunications.
q. Building Services.
r. Building Operations.
s. University Work Related Policies.
t. Contractor Contacts.
u. University Contacts.
v. University Process Forms.

1) Key Request Form.
2) Access Control Badge Application Form.
3) Utility Interruption Request Form.
4) Utility Start-Up Form.
5) Fire Alarm/ Sprinkler Disable Request Form.
6) Hot Work Permit Form.
7) Anschutz Medical Campus (AMC) Street and Parking Lot Closure Form.
8) Indoor Air Quality (IAQ) Plan.
9) IAQ Planning Checklist.
10) IAQ Inspection Checklist.
11) Request for Variance.

4. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.

C. LEED Coordination Conference: For projects pursuing LEED certification, schedule and conduct a LEED coordination conference before starting construction, at a time convenient to University Architect/Engineer, and Contractor.

1. Attendees: Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work and include the following:

   a. University Project Manager.
   b. Architect/Engineer and their consultants.
   c. Contractor’s project manager, superintendent and LEED coordinator.
   d. Major subcontractors and suppliers.
   e. Other concerned parties.

2. Agenda: Discuss items of significance that could affect meeting requirements for LEED certification, including the following:

   a. LEED Project Checklist.
   b. Procedures for selecting and monitoring status for achieving Project goals related to recycled content and regional materials.
   c. General requirements for LEED-related procurement and documentation.
   d. Project closeout requirements and LEED certification procedures.
   e. Role of LEED coordinator.
   f. Construction waste management.
   g. Construction operations and LEED requirements and restrictions.
3. **Minutes:** Entity responsible for conducting meeting will record and distribute meeting minutes.

D. **Preinstallation Conferences:** Conduct a preinstallation conference at Project site for installations, systems or assemblies where required by individual Specification Sections, or where deemed necessary by Contractor.

1. **Attendees:** Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect/Engineer of scheduled meeting dates.

2. **Agenda:** Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following, as appropriate:
   
   b. Options.
   c. Related RFIs.
   d. Related Change Orders.
   e. Purchases.
   f. Deliveries.
   g. Submittals.
   h. LEED requirements, for projects pursuing LEED certification.
   i. Review of mockups.
   j. Possible conflicts.
   k. Compatibility requirements.
   l. Time schedules.
   m. Weather limitations.
   n. Manufacturer's written instructions.
   o. Warranty requirements.
   q. Acceptability of substrates.
   r. Temporary facilities and controls.
   s. Space and access limitations.
   t. Regulations of authorities having jurisdiction.
   u. Testing and inspecting requirements.
   v. Installation procedures.
   w. Coordination with other work.
   x. Required performance results.
   y. Protection of adjacent work.
   z. Protection of construction and personnel.

3. **Record significant conference discussions, approved schedules, agreements, and disagreements, including required corrective measures and actions.**

4. **Reporting:** Distribute minutes of the meeting to each party present and to other parties requiring information, including University Project Manager and Architect/Engineer.

5. **Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.**

First option in Paragraph below is for Large Projects; second option for Small Projects.

E. **Project Closeout Conference:** Schedule and conduct a project closeout conference, at a time convenient to University and Architect/Engineer, but no later than [90][30] calendar days prior to the scheduled date of Substantial Completion or Partial Substantial Completion.

1. Conduct the conference to review requirements and responsibilities related to Project closeout.
2. Attendees: Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work and include the following:

   a. University Project Manager.
   c. Architect/Engineer and their consultants.
   d. Contractor’s project manager and superintendent.
   e. Major subcontractors and suppliers.
   f. Other concerned parties.

3. Agenda: Discuss items of significance that could affect or delay Project closeout, including the following:

   a. Procedures related to:
      1) Notice of Completion, including preparation of Contractor’s punch list.
      2) Final Inspection.
      3) Notice of Substantial Completion.
      4) Notice of Approval of Occupancy/Use.
      5) Supplemental Occupancy/Use Checklist.
      6) Supplemental Acceptance Checklist.
      7) Pre-acceptance Checklists.
      8) Notice of Acceptance.
      9) Settlement and Final Payment.

   b. Preparation of record documents.
   c. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
   d. Submittal of written warranties.
   e. Requirements for completing LEED documentation, for projects pursuing LEED certification.
   f. Requirements for preparing operations and maintenance data.
   g. Requirements for delivery of material samples, attic stock, and spare parts.
   h. Requirements for demonstration and training.
   i. University's partial occupancy requirements.
   j. Installation of University's furniture, fixtures, and equipment.
   k. Responsibility for removing temporary facilities and controls.

4. Minutes: Entity conducting meeting will record and distribute meeting minutes.

F. Progress Meetings: Conduct progress meetings at weekly intervals.

   1. Coordinate dates of meetings with preparation of payment requests.
   2. Attendees: Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work and include the following:

      a. University Project Manager.
      b. University Health Safety Department Representative.
      d. University Campus Building Official.
      e. Architect/Engineer and their consultants.
      f. Contractor’s project manager and superintendent.
      g. Major subcontractors and suppliers.
      h. Other entities concerned with current progress or involved in planning, coordination, or performance of future activities.
i. As needed, University Building Maintenance Operations (BMO), Subject Matter Experts (SME), and University Facility Support Services (FSS) Representatives.

3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

a. Contractor's Construction Schedule:
   1) Review progress since the last meeting.
   2) Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's construction schedule.
   3) Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
   4) Review schedule for next two week period.
   5) Review schedule of deliveries.
   6) Review off-site fabrication.

b. Site Safety.

c. Indoor Air Quality Management monitoring.

d. Quality:
   1) Quality and work standards.
   2) Status of correction of deficient items.
   3) Progress cleaning.
   4) Field observations.

e. Status of submittals.

f. Status of RFIs.

g. Status of Changes including:
   1) Change Order Bulletins.
   2) Change Order Proposals.
   3) Change Orders.
   4) Pending claims and disputes.

h. Status of LEED documentation, for projects pursuing LEED certification.

i. Review present and future needs of each entity present including:
   1) Access.
   2) Site utilization.
   3) Temporary facilities and controls.
   4) Coordination.

4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.

G. Pay Application and Schedule Review Meeting: Conduct review meeting monthly on or about the 25th of each month.

1. Attendees:

   a. University Project Manager.
b. Architect/Engineer.
c. Contractor’s Project Manager, Superintendent and Scheduler.

2. Agenda: Review draft pay application and progress schedule update in accordance with the requirements of Section 01 29 00 “Payment Procedures” and Section 01 32 00 “Construction Progress Documentation.”

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 31 00
SECTION 01 32 00
CONSTRUCTION PROGRESS DOCUMENTATION

A/E: COORDINATE WITH UNIVERSITY PM AND EDIT THIS SECTION BASED ON PROJECT SIZE TO REFLECT THE APPROPRIATE TYPE CONSTRUCTION PROGRESS DOCUMENTATION REQUIRED.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including the following:

1. Startup construction schedule.
2. Contractor's construction schedule.
3. Construction schedule updating reports.
4. Daily construction reports.
5. Monthly project status reports.
6. Material location reports.
7. Site condition reports.
8. Special reports.

B. Related Requirements:

1. Section 01 33 00 "Submittal Procedures" for submitting schedules and reports.
2. Section 01 40 00 "Quality Requirements" for submitting a schedule of tests and inspections.

1.3 DEFINITIONS

A. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources.

1. Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.
2. Predecessor Activity: An activity that precedes another activity in the network.
3. Successor Activity: An activity that follows another activity in the network.

Definitions in remaining paragraphs below are associated with network CPM type schedule. Delete definitions if using only bar type schedule.

Retain option in Paragraph below for CMGC projects consistent with State of Colorado contract.
B. Cost Loading: The allocation of the schedule of values for the completion of an activity as scheduled. The sum of costs for all activities must equal the total Contract Sum [exclusive of profit, overhead, and general conditions costs].

C. CPM: Critical path method, which is a method of planning and scheduling a construction project where activities are arranged based on activity relationships. Network calculations determine when activities can be performed and the critical path of Project.

D. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project duration and contains no float.

E. Event: The starting or ending point of an activity.

F. Float: The measure of leeway in starting and completing an activity.
   1. Float time is not for the exclusive use or benefit of either University or Contractor, but is a jointly owned, expiring Project resource available to both parties as needed to meet schedule milestones and Contract completion date.
   2. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the successor activity.
   3. Total float is the measure of leeway in starting or completing an activity without adversely affecting the planned Project completion date.

G. Resource Loading: The allocation of manpower necessary for the completion of an activity as scheduled.

1.4 INFORMATIONAL SUBMITTALS

A. Format for Submittals: Submit required submittals in the following format:
   1. Working electronic copy of schedule file, where indicated.
   2. PDF electronic file and four paper copies.

B. Startup construction schedule (bar chart).
   1. Approval of cost-loaded, startup construction schedule will not constitute approval of schedule of values for cost-loaded activities.

C. Contractor’s Preliminary Schedule and Startup Network Diagram: Of size required to display entire network for entire construction period. Show logic ties for activities.

D. Contractor's Detailed Construction Schedule: Initial schedule, of size required to display entire schedule for entire construction period.
   1. Submit a working electronic copy of schedule, using software indicated, and labeled to comply with requirements for submittals. Include type of schedule (initial or updated) and date on label.
E. CPM Reports: Concurrent with CPM schedule, submit each of the following reports. Format for each activity in reports shall contain activity number, activity description, cost and resource loading, original duration, remaining duration, early start date, early finish date, late start date, late finish date, and total float in calendar days.

1. Activity Report: List of all activities sorted by activity number and then early start date, or actual start date if known.
2. Logic Report: List of preceding and succeeding activities for all activities, sorted in ascending order by activity number and then early start date, or actual start date if known.
3. Total Float Report: List of all activities sorted in ascending order of total float.
4. Earnings Report: Compilation of Contractor's total earnings from commencement of the Work until most recent Application for Payment.

F. Construction Schedule Updating Reports: Submit draft for discussion at monthly project schedule and pay application review meeting. Submit final report with monthly Application for Payment.

G. Daily Construction Reports: Submit at weekly intervals.

H. Material Location Reports: Submit at monthly intervals.

I. Site Condition Reports: Submit at time of discovery of differing conditions.

J. Special Reports: Submit at time of unusual event.

K. Qualification Data: For scheduling consultant or in-house scheduling expert.

1.5 QUALITY ASSURANCE

A. Scheduling Consultant Qualifications: An experienced specialist in CPM scheduling and reporting, with a minimum of 5 years experience and capability of producing CPM reports and diagrams within 24 hours of Architect/Engineer's request.

B. Prescheduling Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Review methods and procedures related to the preliminary construction schedule and Contractor's construction schedule, including, but not limited to, the following:

1. Review software limitations and content and format for reports.
2. Verify availability of qualified personnel needed to develop and update schedule.
3. Discuss constraints, including phasing, work stages, area separations, interim milestones, and partial University occupancy, as may be applicable.
4. Review delivery dates for University-furnished products.
5. Review schedule for work of University's separate contracts.
6. Review submittal requirements and procedures.
7. Review time required for review of submittals and resubmittals.
8. Review requirements for tests and inspections by independent testing and inspecting agencies.
9. Review time required for Project closeout and University startup procedures, including commissioning activities.
10. Review and finalize list of construction activities to be included in schedule.
11. Review procedures for updating schedule.

1.6 COORDINATION

A. Coordinate Contractor's construction schedule with the schedule of values, list of subcontracts, submittal schedule, progress reports, payment requests, and other required schedules and reports.

1. Secure time commitments for performing critical elements of the Work from entities involved.
2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

PART 2 - PRODUCTS

2.1 CONTRACTOR'S CONSTRUCTION SCHEDULE, GENERAL

A. Time Frame: Extend schedule from date established for commencement of the Work to date of Substantial Completion.

1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date is not permitted. Contract completion date may only be modified by Change Order.

B. Activities: Treat each story or separate area as a separate numbered activity for each main element of the Work. Comply with the following:

1. Activity Duration: Define activities so no activity is longer than 21 calendar days, unless specifically allowed by Architect/Engineer.
2. Procurement Activities: Include procurement process activities for long lead items and major items, requiring a cycle of more than 60 calendar days, as separate activities in schedule. Procurement cycle activities include, but are not limited to, submittals, approvals, purchasing, fabrication, and delivery.
3. Submittal Review Time: Include review and resubmittal times indicated in Section 01 33 00 "Submittal Procedures" in schedule. Coordinate submittal review times in Contractor's construction schedule with submittal schedule.
4. Startup and Testing Time: Include adequate time for startup, testing and commissioning.
5. Substantial Completion: Indicate completion in advance of date established for Substantial Completion, and allow time for Architect/Engineer's administrative procedures necessary for issuing Notice of Substantial Completion.

C. Constraints: Include the following constraints and work restrictions as indicated in the Contract Documents and as applicable in schedule; show how the sequence of the Work is affected.

1. Phasing: Arrange list of activities on schedule by phase.
2. Work by University: Include a separate activity for each portion of the Work performed by University.
3. Products Ordered in Advance: Include a separate activity for each product. Include delivery date indicated in Section 01 10 00 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
4. University-Furnished Products: Include a separate activity for each product. Include delivery date indicated in Section 01 10 00 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
5. Work Restrictions: Show the effect of the following items, as applicable, on the schedule:
   a. Coordination with existing construction.
   b. Limitations of continued occupancies.
   c. Uninterruptible services.
   d. Partial occupancy before Substantial Completion.
   e. Use of premises restrictions.
   f. Environmental control.

6. Work Stages: Indicate important stages of construction for each major portion of the Work, including, but not limited to, the following:
   a. Submittals.
   b. Mockups.
   c. Fabrication.
   d. Sample testing.
   e. Deliveries.
   f. Installation.
   g. Tests and inspections.
   h. Building flush-out.
   i. Startup and placement into final use and operation.

7. Construction Areas: As applicable, identify each major area of construction for each major portion of the Work. Indicate where each construction activity within a major area must be sequenced or integrated with other construction activities to provide for the following:
   a. Structural completion.
   b. Temporary enclosure and space conditioning.
   c. Permanent space enclosure.
   d. Completion of mechanical installation.
   e. Completion of electrical installation.
   f. Substantial Completion.

D. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Commencement of Work, Substantial Completion, Notice of Occupancy and Use, and Final Acceptance. As applicable, also include milestones for Partial Substantial Completion and Partial Notice of Occupancy and Use.

E. Recovery Schedule: When periodic update indicates the Work is 14 or more calendar days behind the current approved schedule, submit a separate recovery schedule indicating means by which Contractor intends to regain compliance with the schedule. Indicate changes to working hours, working days, crew sizes, and equipment required to achieve compliance, and date by which recovery will be accomplished.

F. Computer Scheduling Software: Prepare schedules using current version of a program that has been developed specifically to manage construction schedules and as approved by University and Architect/Engineer.

2.2 STARTUP CONSTRUCTION SCHEDULE (BAR CHART)

Delete this Article for both Large Projects utilizing CPM schedules and very Small Projects with a duration of less than 90 calendar days.

A. Bar-Chart Schedule: Submit startup, horizontal, bar-chart-type construction schedule within seven calendar days of date established for commencement of the Work.
B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line. Outline significant construction activities for first 90 calendar days of construction. Include skeleton diagram for the remainder of the Work and a cash requirement prediction based on indicated activities.

2.3 CONTRACTOR’S CONSTRUCTION SCHEDULE (BAR CHART OR GANTT CHART)

Delete this Article for Large Projects utilizing CPM schedule.

A. Bar-Chart or Gantt-Chart Schedule: Submit startup, horizontal, bar-chart-type or a comprehensive, fully developed, horizontal, Gantt-chart-type construction schedule within 30 calendar days of date established for commencement of the Work. Base schedule on the startup construction schedule and additional information received since the start of Project.

B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line. Use the same breakdown of construction activities as indicated in the Schedule of Values.

1. For construction activities that require three months or longer to complete, indicate an estimated completion percentage in 10 percent increments within time bar. With each required construction schedule update, place a contrasting mark in each bar to indicate actual completion.

2.4 CONTRACTOR’S CONSTRUCTION SCHEDULE (CPM SCHEDULE)

Retain this Article for Large Projects; delete for Small Projects not utilizing CPM schedule.

A. General: Prepare network diagrams using AON (activity-on-node) format.

B. Contractor’s Preliminary Schedule and Startup Network Diagram: Submit diagram within 14 calendar days of date established for commencement of the Work. Outline significant construction activities for the first 90 calendar days of construction. Include skeleton diagram for the remainder of the Work and a cash requirement prediction based on indicated activities.

C. CPM Schedule: Prepare Contractor's detailed construction schedule using a cost- and resource-loaded, time-scaled CPM network analysis diagram for the Work.

1. Develop network diagram and submit CPM schedule within 45 calendar days after date established for commencement of the Work.

   a. Failure to include any work item required for performance of this Contract shall not excuse Contractor from completing all work within applicable completion dates, regardless of Architect/Engineer's approval of the schedule.

2. Conduct educational workshops to train and inform key Project personnel, including subcontractors' personnel, in proper methods of providing data and using CPM schedule information.

3. Establish procedures for monitoring and updating CPM schedule and for reporting progress. Coordinate procedures with progress meeting and payment request dates.

4. Use "one workday" as the unit of time for individual activities. Indicate nonworking days and holidays incorporated into the schedule in order to coordinate with the Contract Time.
D. CPM Schedule Preparation: Prepare a list of all activities required to complete the Work. Using contractor’s preliminary schedule and startup network diagram, prepare a skeleton network to identify probable critical paths.

1. Activities: Indicate the estimated time duration, sequence requirements, and relationship of each activity in relation to other activities. Include estimated time frames for the following activities:
   a. Preparation and processing of submittals.
   b. Mobilization and demobilization.
   c. Purchase of materials.
   d. Delivery.
   e. Fabrication.
   f. Utility interruptions.
   g. Installation.
   h. Work by University that may affect or be affected by Contractor's activities.
   i. Testing and commissioning.
   j. Punch list and final completion.
   k. Activities occurring following final completion.

2. Critical Path Activities: Identify critical path activities, including those for interim completion dates. Scheduled start and completion dates shall be consistent with Contract milestone dates.

3. Processing: Process data to produce output data on a computer-drawn, time-scaled network. Revise data, reorganize activity sequences, and reproduce as often as necessary to produce the CPM schedule within the limitations of the Contract Time.

4. Format: Mark the critical path. Locate the critical path near center of network; locate paths with most float near the edges.
   a. Subnetworks on separate sheets are permissible for activities clearly off the critical path.

5. Cost- and Resource-Loading of CPM Schedule: Assign cost to construction activities on the CPM schedule. Do not assign costs to submittal activities. Assign activities and costs for mobilization, bonds, permits and insurance. Obtain Architect/Engineer's approval prior to assigning costs to material procurement activities if intending to bill for materials stored on site. Assign costs under main subcontracts for testing and commissioning activities, operation and maintenance manuals, punch list activities, Project record documents, LEED documentation, and demonstration and training (if applicable), in the amount of not more than 5 percent of the Contract Sum.
   a. Each activity cost shall reflect an appropriate value subject to approval by Architect/Engineer.
   b. Total cost assigned to activities shall equal the total Contract Sum [exclusive of general conditions, overhead and profit costs].
   c. As requested by University, code activities to permit sorting of Schedule of Values by CSI Division, funding sources, sub-trades, building systems, Bid Packages as applicable, or combinations thereof.
   d. Resource load activities with forecasted manpower and code to permit production of graphically depicted manpower report. Show manpower effort for each subcontractor and as an aggregate for each month.

E. Contract Modifications: For each proposed contract modification and concurrent with its submission, prepare a time-impact analysis using a network fragment to demonstrate the effect of the proposed change on the overall project schedule.
F. Initial Issue of Schedule: Prepare initial network diagram from a sorted activity list indicating straight "early start-total float." Identify critical activities. Prepare tabulated reports showing the following:

1. Contractor or subcontractor and the Work or activity.
2. Description of activity.
3. Main events of activity.
4. Immediate preceding and succeeding activities.
5. Early and late start dates.
6. Early and late finish dates.
7. Activity duration in workdays.
8. Total float or slack time.
10. Dollar value of activity (coordinated with the schedule of values).

G. Schedule Updating: Concurrent with making revisions to schedule, prepare tabulated reports showing the following:

1. Identification of activities that have changed.
2. Changes in early and late start dates.
3. Changes in early and late finish dates.
5. Changes in the critical path.
6. Changes in total float or slack time.

H. Summary Reports: With each schedule update, at a minimum provide the following hard copy cost and resource reports:

1. Cost report showing activity dollar value, dollar value of work in place to-date and dollar value for current period.
2. Cost report showing activity dollar value, dollar value of work in place to-date, and dollar value for current period summarizing to schedule of values.
3. Resource report showing man-day allocations by specific trade on each activity.
5. Cash flow report showing monthly projections of expenditures.
6. Narrative schedule report documenting:
   a. Description of the actual work accomplished during the reporting period.
   b. Description of any problem areas.
   c. Description of current and anticipated delays with recommended corrective actions to mitigate such delays.
   d. A list of proposed modifications, additions, deletions, and changes in logic to the approved construction schedule.

2.5 REPORTS

A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at Project site:

1. List of subcontractors at Project site.
2. List of separate contractors at Project site.
3. Approximate count of personnel at Project site.
4. Equipment at Project site.
5. Material deliveries.
6. High and low temperatures and general weather conditions, including presence of rain or snow.
7. Accidents.
8. Meetings and significant decisions.
9. Unusual events (see special reports).
10. Stoppages, delays, shortages, and losses.
11. Meter readings and similar recordings.
13. Orders and requests of authorities having jurisdiction.
14. Change Orders received and implemented.
15. Services connected and disconnected.
16. Equipment or system tests and startups.
17. Partial completions and occupancies.
18. Substantial Completions authorized.

Retain the following paragraph for Large Projects only.

B. Monthly Project Status Report: Prepare a monthly project status report including the following:

1. Current status of Project:
   a. Schedule.
   b. Cost.
   c. MBE and WBE participation, as applicable.
   d. RFI’s.
   e. Submittals.
   f. Manpower.
   g. Safety.

2. Narrative of progress achieved in previous month, activities anticipated for the next month, and
   issues affecting the rate of progress.
3. Progress photographs in accordance with Section 01 32 33 “Photographic Documentation.”

C. Material Location Reports: At monthly intervals, prepare and submit a comprehensive list of materials
delivered to and stored at Project site. List shall be cumulative, showing materials previously reported
plus items recently delivered. Include with list a statement of progress on and delivery dates for materials
or items of equipment fabricated or stored away from Project site. Indicate the following categories for
stored materials:

1. Material stored prior to previous report and remaining in storage.
2. Material stored prior to previous report and since removed from storage and installed.
3. Material stored following previous report and remaining in storage.

D. Site Condition Reports: Immediately on discovery of a difference between site conditions and the
Contract Documents, prepare and submit a detailed report. Submit with a Request for Information.
Include a detailed description of the differing conditions, together with recommendations for changing
the Contract Documents.

2.6 SPECIAL REPORTS

A. General: Submit special reports directly to University within one calendar day(s) of an occurrence.
   Distribute copies of report to parties affected by the occurrence.

B. Reporting Unusual Events: When an event of an unusual and significant nature occurs at Project site,
   whether or not related directly to the Work, prepare and submit a special report. List chain of events,
persons participating, response by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise University in advance when these events are known or predictable.

PART 3 - EXECUTION

3.1 CONTRACTOR'S CONSTRUCTION SCHEDULE

A. Scheduling Consultant: Engage a consultant to provide planning, evaluation, and reporting using CPM scheduling.

   1. In-House Option: University may waive the requirement to retain a consultant if Contractor employs skilled personnel with experience in CPM scheduling and reporting techniques. Submit qualifications.
   2. Meetings: Scheduling consultant shall attend all meetings related to Project progress, alleged delays, and time impact.

B. Contractor's Construction Schedule Updating: At monthly intervals, update schedule to reflect actual construction progress and activities. Issue schedule draft update schedule for discussion and review at monthly project progress schedule and pay application review meeting.

   1. Revise schedule immediately after each meeting and issue updated schedule concurrently with submittal of monthly Application for Payment.
   2. Include summary reports with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
   3. As the Work progresses, indicate final completion percentage for each activity.
   4. Schedule updates may change logic but may not change milestone or critical path without prior approval of University and Architect/Engineer.

C. Distribution: Distribute copies of approved schedule to Architect/Engineer University, separate contractors, testing and inspecting agencies, and other parties identified by Contractor with a need-to-know schedule responsibility.

   1. Post copies in Project meeting rooms and temporary field offices.
   2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction activities.

END OF SECTION 01 32 00
SECTION 01 32 33

PHOTOGRAPHIC DOCUMENTATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Preconstruction photographs.
2. Periodic construction photographs.
3. Final completion construction photographs.

B. Related Requirements:

1. Section 01 33 00 "Submittal Procedures" for submitting photographic documentation.
2. Section 01 77 00 "Closeout Procedures" for submitting photographic documentation as project record documents at Project closeout.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For photographer.

B. Key Plan: Submit key plan of Project site and building with notation of vantage points marked for location and direction of each photograph. Indicate elevation or story of construction. Include same information as corresponding photographic documentation.

C. Digital Photographs: Submit image files within three business days of taking photographs.

1. Digital Camera: Minimum sensor resolution of 12 megapixels.
2. Format: Minimum 3200 by 2400 pixels, in unaltered original files, with same aspect ratio as the sensor, uncropped, date and time stamped, in folder named by date of photograph, accompanied by key plan file.
3. Identification: Provide the following information with each image description in file metadata tag:

   a. Name of Project.
   b. Name and contact information for photographer.
   c. Name of Architect/Engineer.
   d. Name of Contractor.
   e. Date photograph was taken.
   f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
   g. Unique sequential identifier keyed to accompanying key plan.
1.4 QUALITY ASSURANCE

A. Photographer Qualifications: An individual who has been regularly engaged as a professional photographer of construction projects for not less than three years.

1.5 USAGE RIGHTS

A. Obtain and transfer copyright usage rights from photographer to University for unlimited reproduction of photographic documentation.

PART 2 - PRODUCTS

2.1 PHOTOGRAPHIC MEDIA

A. Digital Images: Provide images in JPG format, produced by a digital camera with minimum sensor size of 12 megapixels, and at an image resolution of not less than 3200 by 2400 pixels.

PART 3 - EXECUTION

3.1 CONSTRUCTION PHOTOGRAPHS

A. Photographer: Engage a qualified photographer to take construction photographs.

B. General: Take photographs using the maximum range of depth of field, and that are in focus, to clearly show the Work. Photographs with blurry or out-of-focus areas will not be accepted.

1. Maintain key plan with each set of construction photographs that identifies each photographic location.

C. Digital Images: Submit digital images exactly as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.

1. Date and Time: Include date and time in file name for each image.
2. Field Office Images: Maintain one set of images accessible in the field office at Project site, available at all times for reference. Identify images in the same manner as those submitted to Architect/Engineer.

D. Preconstruction Photographs: Before starting construction, take photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by Architect/Engineer.

In consultation with University Project Manager, revise number of photographs required in subparagraphs below based on size of project.

1. Flag construction limits before taking construction photographs.
2. Take [20] <Insert number> photographs to show existing conditions adjacent to property before starting the Work.
3. Take [20] <Insert number> photographs of existing buildings either on or adjoining property to accurately record physical conditions at start of construction.
4. Take additional photographs as required to record settlement or cracking of adjacent structures, pavements, and improvements.

E. Periodic Construction Photographs: Take [20] <Insert number> photographs monthly, coinciding with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last photographs were taken.

F. Architect/Engineer-Directed Construction Photographs: From time to time, Architect/Engineer will instruct photographer about number and frequency of photographs and general directions on vantage points. Select actual vantage points and take photographs to show the status of construction and progress since last photographs were taken.

G. Final Completion Construction Photographs: Take [20] <Insert number> color photographs after date of Substantial Completion for submission as project record documents. Architect/Engineer will inform photographer of desired vantage points.

1. Do not include date stamp.

H. Additional Photographs: University through Architect/Engineer may request photographs in addition to periodic photographs specified. Additional photographs will be paid for by Change Order and are not included in the Contract Sum.

1. Three business days' notice will be given, where feasible.
2. In emergency situations, take additional photographs within 24 hours of request.
3. Circumstances that could require additional photographs include, but are not limited to, the following:
   a. Special events planned at Project site.
   b. Immediate follow-up when on-site events result in construction damage or losses.
   c. Photographs to be taken at fabrication locations away from Project site. These photographs are not subject to unit prices or unit-cost allowances.
   d. Substantial Completion of a major phase or component of the Work.
   e. Extra record photographs at time of final acceptance.
   f. University's request for special publicity photographs.

END OF SECTION 01 32 33
SECTION 01 33 00

SUBMITTAL PROCEDURES

RETAIN OPTIONS FOR EITHER PAPER OR ELECTRONIC SUBMITTALS WHERE INDICATED BASED ON PROJECT SIZE AND THE ANTICIPATED CAPABILITIES OF QUALIFIED CONTRACTORS. MAKE SELECTION IN CONSULTATION WITH UNIVERSITY PROJECT MANAGER.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Related Requirements:

1. Section 01 29 00 "Payment Procedures" for submitting Applications for Payment and the schedule of values.
2. Section 01 32 00 "Construction Progress Documentation" for submitting schedules and reports, including Contractor's construction schedule.
3. Section 01 78 23 "Operation and Maintenance Data" for submitting operation and maintenance manuals.
4. Section 01 78 39 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
5. Division 02 through 33 for additional submittal requirements specific to indicated Specification Sections.

1.3 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals." Submittals not specifically indicated as informational submittals are considered to be action submittals.

B. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals" and include, but are not limited to:

1. Schedules.
2. Permits.
3. Applications for payment.
4. Performance and payment bonds.
5. Insurance certificates.
7. Schedule of Values.
8. Inspection and test results.
10. Coordination drawings.

C. File Transfer Protocol (FTP): Communications protocol that enables transfer of files to and from another computer over a network and that serves as the basis for standard Internet protocols. An FTP site is a portion of a network located outside of network firewalls within which internal and external users are able to access files.


1.4 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Architect/Engineer and additional time for handling and reviewing submittals required by those corrections.

1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.

For Small Projects of short duration where a startup construction schedule is not required, delete "Initial Submittal" Subparagraph below.

2. Initial Submittal: Submit concurrently with startup construction schedule and within 30 calendar days of Notice to Proceed or Commencement of Work, but not later than submittal of first application for payment. Include submittals required during the first 90 calendar days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.

3. Final Submittal: Submit concurrently with the first complete submittal of Contractor's construction schedule.

a. Submit revised submittal schedule to reflect changes in current status and timing for submittals.

4. Format: Arrange the following information in a tabular format:

a. Scheduled date for first submittal.
b. Specification Section number and title.
c. Submittal category: Action; informational.
d. Name of subcontractor.
e. Description of the Work covered.
f. Scheduled date for resubmittal.
g. Scheduled date for Architect/Engineer's final release or approval.
h. Scheduled date of fabrication.
For Large Projects and those employing CMGC delivery method, retain three Subparagraphs below where CPM construction schedules are required.

i. Scheduled dates for purchasing.
j. Scheduled dates for installation.
k. Activity or event numbers.

1.5 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Architect/Engineer's Digital Data Files: Electronic digital data files of the Contract Drawings will be provided by Architect/Engineer for Contractor's use in preparing submittals.

1. Architect/Engineer will furnish Contractor one set of digital data drawing files of the Contract Drawings for use in preparing Shop Drawings [and Project record drawings].

   a. Architect/Engineer makes no representations as to the accuracy or completeness of digital data drawing files as they relate to the Contract Drawings.
   b. Digital Drawing Software Program: The Contract Drawings are available in <Insert name and version of digital drawing software program and operating system>.
   c. Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to University and Architect/Engineer.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities. Transmit for review with sufficient time to avoid construction delays.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

   a. Architect/Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect/Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 14 calendar days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect/Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
3. Resubmittal Review: Allow 14 calendar days for review of each resubmittal.
4. Large and/or Complex Submittals: For large and/or complex submittals, as determined by the Architect/Engineer and for submittals that require sequential reviews by Architect/Engineer’s consultants, a review period greater than 14 calendar days may be required. Architect/Engineer and Contractor shall identify such submittals upon submission of the submittal schedule and determine a mutually agreed upon review period.
D. Paper Submittals: Place a permanent label or title block on each submittal item for identification.

1. Indicate name of firm or entity that prepared each submittal on label or title block.
2. Provide a space approximately [6 by 8 inches] <Insert dimensions> on label or beside title block to record Contractor's review and approval markings and action taken by Architect/Engineer.
3. Include the following information for processing and recording action taken:
   a. Project name.
   b. Date.
   c. Name of Architect/Engineer.
   d. Name and address of Contractor.
   e. Name and address of subcontractor.
   f. Name and address of supplier.
   g. Name of manufacturer.
   h. Submittal number or other unique identifier, including revision identifier.
      1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 061000.01.A).
   i. Number and title of appropriate Specification Section.
   j. Drawing number and detail references, as appropriate.
   k. Location(s) where product is to be installed, as appropriate.
   l. Other necessary identification.
4. Additional Paper Copies: Unless additional copies are required for final submittal, and unless Architect/Engineer observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.
   a. Submit one copy of submittal to concurrent reviewer in addition to specified number of copies to Architect/Engineer.
5. Transmittal for Paper Submittals: Assemble each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. Architect/Engineer will return without review submittals received from sources other than Contractor.
   a. Transmittal Form for Paper Submittals: Provide locations on form for the following information:
      1) Project name.
      2) Date.
      3) Destination (To:).
      4) Source (From:).
      5) Name and address of Architect/Engineer.
      6) Name and address of Contractor.
      7) Name of firm or entity that prepared submittal.
      8) Names of subcontractor, manufacturer, and supplier.
      9) Category and type of submittal.
      10) Submittal purpose and description.
      11) Specification Section number and title.
      12) Specification paragraph number or drawing designation and generic name for each of multiple items.
      13) Drawing number and detail references, as appropriate.
SUBMITTAL PROCEDURES

14) Indication of full or partial submittal.
15) Transmittal number.
16) Submittal and transmittal distribution record.
17) Remarks.
18) Contractor's certification that information complies with Contract Document requirements.
19) Signature of transmitter.

For Large Projects retain "Electronic Submittals" Paragraph and Subparagraphs below.

E. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.

2. Name file with submittal number or other unique identifier, including revision identifier.
   a. File name shall use project identifier and Specification Section number followed by a dash and then a sequential number (e.g., LNHS-061000-01). Resubmittals shall include an alphabetic suffix after another dash (e.g., LNHS-061000-01-A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect/Engineer.

Select first option below for CM/GC and other Large Projects which employ project management software. The use of project management software is required in the Construction Manager/General Contractor Agreement CMGC, State Form SC-6.4.

4. Transmittal Form for Electronic Submittals: Use [software-generated form from electronic project management software] [electronic form] acceptable to University, containing the following information:
   a. Project name.
   b. Date.
   c. Name and address of Architect/Engineer.
   d. Name and address of Contractor.
   e. Name of firm or entity that prepared submittal.
   f. Names of subcontractor, manufacturer, and supplier.
   g. Category and type of submittal.
   h. Submittal purpose and description.
   i. Specification Section number and title.
   j. Specification paragraph number or drawing designation and generic name for each of multiple items.
   k. Drawing number and detail references, as appropriate.
   l. Location(s) where product is to be installed, as appropriate.
   m. Related physical samples submitted directly.
   n. Indication of full or partial submittal.
   o. Transmittal number.
   p. Submittal and transmittal distribution record.
   q. Other necessary identification.
   r. Contractor's certification that information complies with Contract Document requirements.
   s. Remarks.

F. Options: Identify options requiring selection by Architect/Engineer.
G. Deviations and Additional Information: On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Architect/Engineer on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

H. Contractor Certification: On transmittal include Contractor's certification that information complies with Contract Document requirements.

I. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.
   1. Note date and content of previous submittal.
   2. Note date and content of revision in label or title block and clearly indicate extent of revision.
   3. Resubmit submittals until they are marked with approval notation from Architect/Engineer's action stamp.

J. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

K. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Architect/Engineer's action stamp.

L. Record Documents: Retain complete additional copies of submittals on Project site to be submitted as record documents in accordance with requirements of Section 01 78 39 “Project Record Documents.”

M. Legibility: Provide clear and legible submittals. Submittals that are blurry or are for any reason unreadable will be returned without action.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

Retain subparagraphs below for electronic submittals

1. Post electronic submittals as PDF electronic files directly to [Project Management Software Web site] specifically established for Project.

Retain “Action Submittals” and “Informational Submittals” subparagraphs below as default requirements for paper copies of submittals.

2. Action Submittals: Submit three paper copies of each submittal to Architect/Engineer and one to University unless otherwise indicated. Architect/Engineer will return one copy.
3. Informational Submittals: Submit two paper copies of each submittal to Architect/Engineer and one to University unless otherwise indicated. Architect/Engineer will not return copies.
4. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:
   a. Manufacturer's catalog cuts.
   b. Manufacturer's product specifications.
   c. Manufacturer's installation instructions.
   d. Manufacturer's printed recommendations.
   e. Standard color charts.
   f. Statement of compliance with specified referenced standards.
   g. Statement of compliance with specified trade association standards.
   h. Testing by recognized testing agency.
   i. Application of testing agency labels and seals.
   j. Notation of coordination requirements.
   k. Notation of dimensions verified by field measurement.

4. For equipment, include the following in addition to the above, as applicable:
   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
   d. Rough-in diagrams and templates indicating clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.
7. Submit additional copies of Product Data as required complying with requirements of Section 01 78 39 “Project Record Documents.”

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Highlight, encircle or otherwise indicate deviations from Contract Documents. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data, unless submittal based on Architect/Engineer's digital data drawing files is otherwise permitted. Standard information prepared without specific reference to the Project is not considered a shop drawing.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
   a. Identification of products.
   b. Schedules.
   c. Compliance with specified standards.
   d. Notation of coordination requirements.
   e. Notation of dimensions established by field measurement.
   f. Relationship and attachment to adjoining construction clearly indicated.
   g. Seal and signature of professional engineer if specified.
2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches, but no larger than size of Construction Drawings.

3. BIM File Incorporation: Develop and incorporate Shop Drawing files into Building Information Model established for Project.
   a. Prepare Shop Drawings in the following format: Same digital data software program, version, and operating system as the original Drawings.
   b. Refer to Section 01 31 00 "Project Management and Coordination" for requirements for coordination drawings.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.
   1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
   2. Mount, display or package Samples in the manner specified to facilitate review of qualities indicated. Prepare Samples to match the Architect/Engineer's Sample.
   3. Identification: Attach label on unexposed side of Samples that includes the following:
      a. Generic description of Sample.
      b. Product name and name of manufacturer.
      c. Sample source.
      d. Number and title of applicable Specification Section.
      e. Specification paragraph number and generic name of each item.
      f. Compliance with recognized standards.
      g. Availability and delivery time.

4. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for record.
5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
   a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Architect/Engineer will return submittal with options selected.
6. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.
a. Number of Samples: Submit three sets of Samples. Architect/Engineer will retain two Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a project record sample.

1) Submit a single Sample where assembly details, workmanship, fabrication techniques, connections, operation, and other similar characteristics are to be demonstrated.
2) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

7. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.

b. Samples not incorporated into the Work, or otherwise designated as University's property, are the property of Contractor.

8. Distribution of Samples: Prepare and distribute additional sets to Subcontractors, manufacturers, fabricators, suppliers, Installers, and others as required for performance of the Work. Show distribution on transmittal forms.

9. Field Samples and Mock-Ups: Field Samples and mock-ups specified in individual Sections are full-size examples erected on site to illustrate finishes, coatings, or finish materials and to establish the standard by which the Work will be judged.

E. Selection of Related Materials: Where selections of colors, patterns, textures are specified to be made by Architect/Engineer, assemble complete samples of all specified or approved products for all Specification Sections and submit to Architect/Engineer. Review specifications and assemble all such samples for a combined single submittal. Indicate on the transmittal the latest date for selections to be made for each item to permit delivery of material in accordance with Progress Schedule. Architect/Engineer's action is limited solely to the specified selections or rejection of submittal items not in accordance with Specifications.

F. Coordination Drawing Submittals: Comply with requirements specified in Section 01 31 00 "Project Management and Coordination."

G. Contractor's Construction Schedule: Comply with requirements specified in Section 01 32 00 "Construction Progress Documentation."

H. Application for Payment and Schedule of Values: Comply with requirements specified in Section 01 29 00 "Payment Procedures."

I. Test and Inspection Reports and Schedule of Tests and Inspections Submittals: Comply with requirements specified in Section 01 40 00 "Quality Requirements."

J. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Section 01 77 00 "Closeout Procedures."

K. Maintenance Data: Comply with requirements specified in Section 01 78 23 "Operation and Maintenance Data."

L. LEED Submittals: For project required to obtain LEED certification, comply with requirements specified in Division 01 Section "Sustainable Design Requirements."
M. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.

N. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

O. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

P. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

Q. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

R. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

S. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

T. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

U. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:

1. Name of evaluation organization.
2. Date of evaluation.
3. Time period when report is in effect.
4. Product and manufacturers' names.
5. Description of product.
6. Test procedures and results.
7. Limitations of use.

V. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

W. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

X. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.
Y. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.2 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect/Engineer.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit three paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

Retain first subparagraph below when Project utilizes BIM through the Construction Stage and delegated-design drawings and data will be incorporated into the BIM.

C. BIM File Incorporation: Incorporate delegated-design drawing and data files into Building Information Model established for Project.

1. Prepare delegated-design drawings in the following format: Same digital data software program, version, and operating system as the original Drawings.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect/Engineer. Submittals received without Contractor's substantive review and approval stamp will be rejected and returned to the Contractor.

B. Project Closeout and Maintenance Material Submittals: See requirements in Section 01 77 00 "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.
3.2 ARCHITECT/ENGINEER'S ACTION

A. Action Submittals: Architect/Engineer will review each submittal, make marks to indicate corrections or revisions required, and return it. Architect/Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action.

B. Informational Submittals: Architect/Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect/Engineer will forward each submittal to appropriate party.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect/Engineer.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may be returned by the Architect/Engineer without action.

END OF SECTION 01 33 00
SECTION 01 35 44

SPECIAL PROCEDURES FOR ENVIRONMENTAL HEALTH AND SAFETY AND FIRE AND LIFE SAFETY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes special administrative and procedural requirements related to environmental health and safety.

B. University is Authority Having Jurisdiction (AHJ) for Fire and Life Safety. This responsibility is administered by the University’s Fire and Life Safety Officer.

C. Related Requirements:

1. Section 01 35 46 “Indoor Air Quality Procedures” for procedure related to maintaining indoor air quality during construction.

2. Section 02 81 00 “Transportation/Disposal of Hazardous Materials.”

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 ENVIRONMENTAL HEALTH AND SAFETY AND FIRE AND LIFE SAFETY PROCEDURES

A. Physical, Life, and Fire Safety:

1. All contractors are required to conform to the Federal Occupational Safety and Health Administration (OSHA) regulations for construction (29 CFR 1926). Certain General Industry Standards (29 CFR 1910) may also apply, depending on location of work.

2. Provide an effective health and safety program to control hazards, including but not limited to compressed gases, welding, electrical, safety netting, cranes, scaffolding and supplies on the roof.

3. Provide fire protection in all construction areas to the satisfaction of the Authority Having Jurisdiction.

4. During the construction phase, the Authority Having Jurisdiction may conduct oversight inspections to observe and provide recommendations regarding applicable safety standards. The following minimum items are included:

   a. Do not block exit corridors. Install signage clearly identifying exit routes.

   b. Provide physical barriers with appropriate warning signage to protect public areas from construction work.
c. Conduct daily inspections to eliminate fire hazards and any other safety hazards.
d. Periodic safety inspections will be performed on job sites by the Authority Having Jurisdiction. The Authority Having Jurisdiction for fire safety will present University’s Project Manager with a written summary of the findings who will then take these issues to the Contractor’s superintendent, foreman or other designated representative and return the summary form with documentation of the resolution of safety items to AHJ. Abate deficient items in a timely manner. Include documentation and resolution of safety items presented in weekly Progress Meeting minutes. Inspections by University AHJ are spot-checks only. They are not all encompassing. These inspections and recommendations do not relieve the Contractor from obligations related to safe work practices, as required under federal law.
e. AHJ has the right to access the site at all times. Should a potential threat to personnel or property be observed, AHJ may require the hazard related operation immediately altered until adequate safeguards are addressed.
f. Supply AHJ, through the University Project Manager, with a copy of Contractor’s weekly safety meeting minutes and safety inspection reports.
g. Provide signs used for proper identification of construction areas.
h. Provide adequate number of appropriately rated fire extinguishers to be available on-site for emergency use in the construction area.
i. Insure standpipes, pull stations, electrical panels, water control valves and fire hydrants are accessible at all times.
j. Post emergency notification phone numbers provided by Contractor and University in all construction areas.
k. Notify University Project Manager of any lost time injuries occurring on University’s property within one (1) calendar day and of any fatalities immediately.
l. Submit copies of all injury reports to AHJ, through University’s Project Manager.
m. Equip construction personnel with personal protective equipment (PPE) where required. Coordinate with University Project Manager to identify where use of PPE will be required.

B. OSHA Hazard Communication Standard:

1. Every Contractor and Subcontractor performing work shall comply with the OSHA Hazard Communication Standard. Compliance includes joint University and Contractor responsibilities for the purpose of providing timely communications and information sharing with regard to hazardous materials, chemicals and chemical sources which may be present on-site or brought in by Contractor.
2. University Project Manager will provide Contractor with the following:
   a. Information regarding known hazardous chemicals and agents or other hazards present at the job site.
   b. University emergency procedures and contact numbers.

3. Provide safety training and environmental surveillance of all workers.
4. Inform and provide University’s Project Manager the following:
   a. Material safety data sheets (MSDS) for all chemicals introduced into the workplace.
   b. Information regarding potential sources of pollutants which may be entrained in University’s air intakes, e.g., roofing tar fumes, nuisance dusts, exhaust from internal combustion engines, welding or cutting fumes, and asbestos - if damaged or encountered during the course of the work.

C. Asbestos and Lead Paint:

1. The presence of asbestos-containing materials and/or paint containing lead on the job site does not mean a problem exists. Areas where asbestos is friable and not contained or lead paint is present or will be caused to be present in airborne or settled dust are of concern.
2. Responsibilities of University and Contractor regarding asbestos and lead paint are as follows:

a. University:

   1) Notify the Contractor of the condition and location(s) where asbestos is known to be present or may reasonably be encountered, e.g., asbestos insulation, ceiling tiles, floor tiles, fire doors, wall and ceiling plasters, concrete, grouting, etc., and lead paint on metal building materials, walls, windows, etc.
   2) Coordinate with Contractor when response action is required by a Subcontractor.
   3) Contract with third party contractor to monitor areas where friable asbestos and/or lead-containing particles are present during construction/renovation projects for its own records and purpose. Monitoring results can be shared with Contractors but are in no way to be used for Contractor employee monitoring.
   4) Final authority on all asbestos-related concerns and contractual arrangements.

b. Contractor:

   1) Notify University's Project Manager of any suspected or existing problem involving asbestos or lead and cease work in that area until University has assessed the situation.
   2) Ensure that undamaged asbestos-containing material and/or material containing lead, not included in the scope of the project, are not damaged.
   3) Train and monitor their own employees, including Asbestos Awareness training and Lead Paint Awareness training, where applicable.
   4) Be responsible for all environmental/industrial hygiene surveillance of its work staff and subcontractors and for required area monitoring where potential contamination of adjacent areas exists.
   5) Prevent problems which can result in asbestos or lead exposure to building occupants.
   6) Coordinate with the University’s EHS Department and Building Maintenance and Operations through University’s Project Manager and perform all activities that may potentially disturb asbestos containing materials in a manner acceptable to the EHS.
   7) Follow State of Colorado regulation, Emission Standards for Asbestos, Part B, Control of Asbestos, “Regulation 8” and OSHA standards regulating exposure to asbestos and lead.
   8) Where applicable, comply with Section 02 81 00 “Transportation/Disposal of Hazardous Materials.”

D. Carcinogens:

   1. Contractor or any Subcontractor shall not knowingly install or cause to be installed any material or product containing carcinogens. Refer to Annual Report on Carcinogens, U.S. Department of Health and Human Services, National Toxicology Program.

E. Hazardous Waste:

   1. All hazardous wastes are to be handled and disposed of according to current EPA and CDPHE guidelines which can be obtained through University Project Manager. Only individuals specifically authorized by University may sign hazardous waste manifests for wastes generated on University’s property. Only University approved transporters and disposal facilities are to be used for transportation and disposal of hazardous wastes.

F. The Control of Hazardous Energy (Lockout/Tagout):
1. Provide and enforce a program and procedures for the control of hazardous energy (lockout/tagout) including, but not limited to, locks, tags and lockout devices. Provide proof that workers have received safety training in the control of hazardous energy through lockout/tagout.

G. Hot Work Operations:

1. Comply with University hot work policy and obtain Hot Work Permit prior to executing any hot work in existing buildings.
2. Notify University Project Manager prior to any hot work on University property.
3. Provide and enforce a program to control fires during hot work operations. Provide appropriately rated fire extinguishers, fire retardant protective covers (when needed), and any other hot work related equipment.

H. Confined Space Entry:

1. Work in compliance with the “Confined Spaced Entry Procedure for Non-University Personnel” whenever any project requires entry into a confined space. A copy of this procedure can be obtained from University EHS through University’s Project Manager.

I. Green Tagging of Work Area:

1. Obtain a Green Tag and Construction Permit from the University Project Manager prior to any work being conducted in a laboratory or on any exhaust ductwork system serving a laboratory. If a Green Tag has been issued, it will be displayed at the entry of the laboratory area. The Green Tag assures that any radioactive, chemical or biological materials have been removed from the laboratory verifying the area is free from hazards to workers. If a Green Tag is not displayed, coordinate tagging with EHS through University’s Project Manager.

END OF SECTION 01 35 44
SECTION 01 35 46

INDOOR AIR QUALITY PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for managing emissions and moisture control during construction.

1.3 DEFINITIONS

A. Sustainable Design Related Terminology: As defined is ASTM E 2114.

B. Adequate Ventilation: Ventilation, including air circulation and air changes, required to cure materials, dissipate humidity, and prevent accumulation of particulates, dust, fumes, vapors, or gases.

C. Hazardous Materials: Any material that is regulated as a hazardous material in accordance with 49 CFR 173, requires a Material Safety Data Sheet (MSDS) in accordance with 29 CFR 1910.1200, or which during end use, treatment, handling, storage, transportation or disposal meets or has components which meet or have the potential to meet the definition of a Hazardous Waste in accordance with 40 CFR 261. Throughout this specification, hazardous material includes hazardous chemicals.

1. Hazardous materials include: pesticides, biocides, and carcinogens as listed by recognized authorities, such as the Environmental Protection Agency (EPA) and the International Agency for Research on Cancer (IARC).

D. Indoor Air Quality (IAQ): The composition and characteristics of the air in an enclosed space that affect the occupants of that space. The indoor air quality of a space refers to the relative quality of air in a building with respect to contaminants and hazards and is determined by the level of indoor air pollution and other characteristics of the air, including those that impact thermal comfort such as air temperature, relative humidity and air speed.

E. Interior Final Finishes: Materials and products that will be exposed at interior, occupied spaces including but not limited to flooring, wallcovering, finish carpentry, and ceilings.

F. Packaged Dry Products: Materials and products that are installed in dry form and are delivered to the site in manufacturer's packaging including but not limited to carpets, resilient flooring, ceiling tiles, and insulation.

G. Wet Products: Materials and products installed in wet form, including paints, sealants, adhesives, special coatings, and other materials which require curing.
1.4 QUALITY ASSURANCE

A. Inspection and Testing Lab Qualifications: Minimum of 5 years experience in performing the types of testing specified herein.

1.5 PRECONSTRUCTION MEETING

A. After award of Contract and prior to the commencement of the Work, schedule and conduct meeting with University and Architect/Engineer to review and discuss the proposed IAQ Management Plan and develop a mutual understanding of detailed requirements for maintaining indoor air quality and environmental protection.

1.6 SUBMITTALS

A. Indoor Air Quality (IAQ) Management Plan: Not less than 10 business days before the Pre-construction meeting, prepare and submit an IAQ Management Plan including, but not limited to, the following:

1. Procedures for control of emissions during construction.
   a. Identify schedule for application of interior finishes.

2. Procedures for moisture control during construction.
   a. Identify porous materials and absorptive materials.
   b. Identify schedule for inspection of stored and installed absorptive materials.

3. Revise and resubmit Plan as required by University.
   a. Approval of Contractor’s Plan will not relieve the Contractor of responsibility for compliance with applicable environmental regulations.

B. Product Data:

1. Submit product data for filtration media used during construction and during operation. Include Minimum Efficiency Reporting Value (MERV).

2. Submit air pressure difference maps for each mode of operation of HVAC.

3. Material Safety Data Sheets: Submit MSDSs for inclusion in Operation and Maintenance Manual for the following products. Coordinate with Section 01 78 23 – Operation and Maintenance Data.
   a. Adhesives.
   b. Floor and wall patching/leveling materials.
   c. Caulking and sealants.
   d. Insulating materials.
   e. Fireproofing and firestopping.
   f. Carpet.
   g. Paint.
   h. Clear finish for wood surfaces.
   i. Lubricants.
   j. Cleaning products.

C. Inspection and Test Reports:

1. Moisture control inspections.
INDOOR AIR QUALITY PROCEDURES

2. Moisture content testing.
3. Moisture penetration testing.
4. Microbial growth testing.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 IAQ MANAGEMENT - EMISSIONS CONTROL

A. Provide point person responsible for the implementation and assurance that the Indoor Air Quality Plan is being implemented.

B. University Indoor Air Quality Plan: Comply with the requirements of the University IAQ Plan, latest version, appended to this Specification Section.

C. Flush-Out: After construction ends, prior to occupancy and with all interior finishes installed, perform a building flush-out by supplying a total air volume of 14,000 cu.ft. of outdoor air per sq.ft. of floor area while maintaining an internal temperature of at least 60 degrees F and relative humidity no higher than 60%.

3.2 IAQ MANAGEMENT - MOISTURE CONTROL

A. Housekeeping:

1. Keep materials dry. Protect stored on-site and installed absorptive materials from moisture damage.
2. Verify that installed materials and products are dry prior to sealing and weatherproofing the building envelope.
3. Install interior absorptive materials only after building envelope is sealed and weatherproofed.

B. Inspections: Document and report results of inspections; state whether or not inspections indicate satisfactory conditions.

1. Examine materials for dampness as they arrive. If acceptable to University, dry damp materials completely prior to installation; otherwise, reject materials that arrive damp.
2. Examine materials for mold as they arrive and reject materials that arrive contaminated with mold.
3. Inspect stored and installed absorptive materials regularly for dampness and mold growth. Inspect weekly.
   a. Where stored on-site or installed absorptive materials become wet, notify Architect/Engineer and University. Inspect for damage. If acceptable to University, dry completely prior to closing in assemblies; otherwise, remove and replace with new materials.
4. Basement: Monitor basement and crawlspace humidity, and dehumidify when relative humidity is greater than 85 percent for more than 2 weeks or at the first sign of mold growth.
5. Site drainage: Verify that final grades of site work and landscaping drain surface water and ground water away from the building.
6. Weather-proofing: Inspect moisture control materials as they are being installed. Include the following:
INDOOR AIR QUALITY PROCEDURES

a. Air and weather-resistant barrier: Verify air and weather-resistant barrier is installed without punctures and/or other damage. Verify air barrier and weather-resistant is sealed completely.
b. Flashing: Verify correct shingling of the flashing for roof, walls, windows, doors, and other penetrations.
c. Insulation layer: Verify insulation is installed without voids.
d. Roofing: In accordance with ASTM D7186 Standard Practice for Quality Assurance Observation of Roof Construction and Repair

7. Plumbing: Verify satisfactory pressure test of pipes and drains is performed before closing in and insulating lines.
8. HVAC: Inspect HVAC system as specified in Section 23 08 00 – Commissioning.
   a. And, inspect HVAC to verify:
      1) Condensate pans are sloped and plumbed correctly.
      2) Access panels are installed to allow for inspection and cleaning of coils and ductwork downstream of coils.
      3) Ductwork and return plenums are air sealed.
      4) Duct insulation is installed and sealed.
      5) Chilled water line and refrigerant line insulation are installed and sealed.

C. Schedule:
   1. Schedule work such that absorptive materials, including but not limited to porous insulations, paper-faced gypsum board, ceiling tile, and finish flooring, are not installed until they can be protected from rain and construction-related water.
   2. Weather-proof as quickly as possible. Schedule installation of moisture-control materials, including but not limited to air and weather-resistant barriers, flashing, exterior sealants and roofing, at the earliest possible time.

D. Testing for Moisture Content: Test moisture content of porous materials and absorptive materials to ensure that they are dry before sealing them into an assembly. Document and report results of testing. Where tests are not satisfactory, dry materials and retest. If satisfactory results cannot be obtained with retest, remove and replace with new materials.
   1. Concrete: Moisture test prior to finish flooring application as specified in Division 09.
   2. Wood: Moisture test as per ASTM D4444 - Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters; unless otherwise indicated acceptable upper limits for wood products are < 20% at center of piece; < 15% at surface.
   3. Gypsum Board, Gypsum Plaster, Insulation, and other absorptive materials: Moisture test with a Pinless Moisture Meter to assess patterns of moisture, if any.

E. Testing for Moisture Penetration:
   1. Windows: Test as per ASTM E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference at 100 percent static-air-pressure difference specified in applicable Division 08 Sections; unless otherwise indicated, acceptable upper limits are no leakage for 15 minutes.
      a. Number of Tests: 1 percent of openings but not less than two.
2. Horizontal Waterproofing (not roofing): Test as per ASTM D5957 Standard Guide for Flood Testing Horizontal Waterproofing Installations; acceptable upper limits are no leakage for 15 minutes.
   a. Test frequency: 100 percent of horizontal waterproofed surfaces.

3. Masonry: Test as per ASTM C1601 Standard Test Method for Field Determination of Water Penetration of Masonry Wall Surfaces; acceptable upper limits are no leakage for 15 minutes.

4. Exterior Walls:
   a. Air tightness of the enclosure test: ASTM E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization or ASTM E1827
      1) Air Leakage: The mean value of the air leakage flow rate calculated from measured data at 0.3 in wg (75 Pa) must not exceed 0.25 cu ft/ minute per square foot of envelope area. Measurements must be referenced at standard conditions of 14.696 psi (101.325 KPa) and 68 deg F.

F. Testing for Support of Microbial Growth: Test and report in accordance with ASTM D6329 Standard Guide for Developing Methodology for Evaluating the Ability of Indoor Materials to Support Microbial Growth Using Static Environmental Chambers. Indicate susceptibility of product or material to colonization and amplification of microorganisms. Identify microorganisms and conditions of testing.

1. Normal conditions: Perform testing at 35 degrees Centigrade and 50 percent relative humidity.
2. Extreme conditions: Perform worst case scenarios screening tests by providing an atmosphere where environmental conditions may be favorable for microbial growth.
3. Perform testing for the following:
   a. Fireproofing material on appropriate substrate.
   b. Ceiling tile.
   c. Wall covering.
   d. Other appropriate material.

END OF SECTION 01 35 46
Indoor Air Quality Plan
February 14, 2009

This plan describes the measures to be taken to provide good indoor air quality (IAQ) during construction and after construction is complete and the occupants have moved into the building. This plan is based on the SMACNA standard “IAQ Guidelines for Occupied Buildings under Construction” and the requirements of the LEED.

It is not the intent of this document to replace or supersede OSHA regulations as to safe construction workplace practices. It remains the responsibility of the Construction Manager and the individual sub-contractors to maintain safe building and site operations. Addition precautions may be necessary when hazardous materials are present.

The plan will address construction IAQ by recommending procedures in five areas of concern, which in turn will allow the building to achieve two LEED program points:

- HVAC system protection
- Containment source control
- Pathway interruption
- Housekeeping
- Scheduling

The following describes the specific measures to be performed in each area of concern:

1. HVAC Protection

   - During construction, provide MERV 13 filters for supply air intake when in use. Provide MERV 8 filters at the return air system openings when in use. Perform frequent maintenance when the HVAC system is being utilized and replace filters as they become loaded, prior to building flushout, and prior to occupancy.
   - When performing construction activities that produce dust, such as drywall sanding, concrete cutting, masonry work, wood sawing or adding insulation, seal off the supply diffusers and return air system openings completely for the duration of the task.
   - Shut down and seal off the supply diffusers and return air ducts during any demolition operations.
   - Whenever the HVAC system is not used during construction, seal off the supply diffusers and return air system openings to prevent the accumulation of dust and debris in the duct system.
   - Do not use the mechanical rooms to store construction or waste materials. Keep rooms clean and neat.
   - Provide periodic duct inspections during construction; if the ducts become contaminated due to inadequate protection, clean the ducts professionally in accordance with NADCA (National Air Duct Cleaning Association) standards.
   - The General Contractor shall take photographs showing measures in place.

2. Source Control

   - Use low VOC products as indicated by the specifications to reduce potential problems.
• Restrict traffic volume and prohibit idling of motor vehicles where emissions could be drawn into the building.
• Utilize electric or natural gas alternatives for gasoline and diesel equipment where possible and practical. Use low-sulfur diesel in lieu of regular diesel.
• Cycle equipment off when not being used or needed.
• Exhaust pollution sources to the outside with portable fan systems. Prevent exhaust from recirculating back into the building from construction equipment outside the building.
• Keep containers of wet products closed as much as possible. Cover or seal containers of waste materials that can release odor or dust.
• Protect stored on-site or installed absorptive building materials from weather and moisture; wrap with plastic and seal tight to prevent moisture absorption.
• The General Contractor shall take photographs showing measures in place.

3. Pathway Interruption

• Provide dust curtains or temporary enclosures to prevent dust from migrating to other areas when applicable.
• Locate pollutant sources as far away as possible from supply ducts and areas occupied by workers when feasible. Supply and exhaust systems may have to be shut down or isolated during such activity.
• During construction, isolate areas of work to prevent contamination of clean or occupied areas. Pressure differentials may be utilized to prevent contaminated air from entering clean areas.
• Depending on weather, ventilation using 100% outside air will be used to exhaust contaminated air directly to the outside during installation of VOC emitting materials.

4. Housekeeping

• Provide regular cleaning concentrating on HVAC equipment and building spaces to remove contaminants from the building prior to occupancy.
• All coils, air filters, fans and ductwork shall remain clean during installation and, if required, will be cleaned prior to performing the testing, adjusting and balancing of the systems.
• Suppress and minimize dust with wetting agents or sweeping compounds. Utilize efficient and effective dust collecting methods such as a damp cloth, wet mop, or vacuum with particulate filters, or wet scrubber.
• Remove accumulations of water inside the building. Protect porous materials such as insulation and ceiling tile from exposure to moisture.
• Thoroughly clean all interior surfaces prior to replacing filters and running HVAC system for system balancing, commissioning and building flushout.
• Provide photographs of the above activities during construction to document compliance.

5. Scheduling and Construction Activity Sequence

• Schedule high pollution activities that utilize high VOC level products (including paints, sealers, insulation, adhesives, caulking and cleaners) to take place prior to installing highly absorbent materials such as ceiling tiles, gypsum wall board, fabric furnishing, carpet and insulation, for example). These materials will act as ‘sinks’ for VOCs, odors and other contaminants, and release them later after occupancy.

PLANNING AND INSPECTION CHECKLISTS

The planning and inspection checklists included in this document are useful to ensure construction IAQ management is planned and implemented correctly. The planning checklist should be completed by the contractor prior to construction. The inspection checklists should be completed monthly to confirm the IAQ management plan is being followed. At the time of inspection, photographs should be taken to support the checklist and to provide audit documentation for the USGBC.
University of Colorado Denver IAQ
February 14, 2009

Planning Checklist
(Must be completed weekly)

Project _________________________________________________________________
Completed by: _________________________________________________________________
(Name & Company)
Date:   ________________________________

1. HVAC Protection
   □ MERV 13 filters at supply air intake
   □ MERV 8 filters at return air openings
   □ Seal supply diffusers and return air during demolition
   □ Seal supply diffusers and return air openings during construction
   □ Mechanical rooms clean and neat
   □ Periodic duct inspections during construction
   □ General Contractor to document with photographs

2. Source Control
   □ Low/no VOC products as indicated by specifications
   □ Restrict vehicle traffic volume and prohibit idling
   □ Utilize electric or natural gas alternatives for gasoline and diesel
   □ Cycle equipment off when not being used or needed
   □ Exhaust pollution sources to the outside
   □ Keep containers of wet products closed
   □ Cover or seal containers of waste materials
   □ Protect absorptive building materials from weather and moisture
   □ Prevent fume migration from construction vehicles and equipment into adjacent buildings
   □ General Contractor to document with photographs

3. Pathway Interruption
   □ Provide dust curtains or temporary enclosures
   □ Locate pollutant sources as far away as possible from supply dusts and areas occupied by workers
   □ General Contractor to document with photographs
   □ Isolate areas of work to prevent contamination of clean or occupied areas
   □ When using VOC emitting materials ventilate using 100% outside air
4. **Housekeeping**

- [ ] Provide regular cleaning, including HVAC equipment
- [ ] If necessary clean HVAC equipment prior to testing, adjusting and balancing the systems
- [ ] Suppress and minimize dust with wetting agents or sweeping compounds
- [ ] Remove accumulations of water inside the building
- [ ] Protect porous materials
- [ ] General Contractor to document with photographs

5. **Scheduling and Construction Activity Sequence**

- [ ] Schedule high pollution activities prior to installing absorbent materials
- [ ] General Contractor to document with photographs

I confirm the checked activities to be proceeding according to the Construction Indoor Air Quality Plan. Items that are not checked will be addressed, initialed and dated once corrective actions have been taken. Items that are not applicable are labeled as such.

Signed: ____________________________________________ Date: ________________

(Contractor)
University of Colorado Denver IAQ
February 14, 2009

Inspection Checklist
(Must be completed weekly)

Project _________________________________________________________________
Completed by: _________________________________________________________________
(Name & Company)
Date:   ________________________________

1. HVAC Protection
   - MERV 13 filters at supply air intake
   - MERV 8 filters at return air openings
   - Seal supply diffusers and return air during demolition
   - Seal supply diffusers and return air openings during construction
   - Mechanical rooms clean and neat
   - Periodic duct inspections during construction
   - General Contractor to document with photographs

2. Source Control
   - Low/no VOC products as indicated by specifications
   - Restrict vehicle traffic volume and prohibit idling
   - Utilize electric or natural gas alternatives for gasoline and diesel
   - Cycle equipment off when not being used or needed
   - Exhaust pollution sources to the outside
   - Keep containers of wet products closed
   - Cover or seal containers of waste materials
   - Protect absorptive building materials from weather and moisture
   - General Contractor to document with photographs

3. Pathway Interruption
   - Provide dust curtains or temporary enclosures
   - Locate pollutant sources as far away as possible from supply dusts and areas occupied by workers
   - General Contractor to document with photographs
   - Isolate areas of work to prevent contamination of clean or occupied areas
   - When using VOC emitting materials ventilate using 100% outside air
   - General Contractor to document with photographs

4. Housekeeping
☐ Provide regular cleaning, including HVAC equipment
☐ If necessary clean HVAC equipment prior to testing, adjusting and balancing the systems
☐ Suppress and minimize dust with wetting agents or sweeping compounds
☐ Remove accumulations of water inside the building
☐ Protect porous materials
☐ General Contractor to document with photographs

5. **Scheduling and Construction Activity Sequence**

☐ Schedule high pollution activities prior to installing absorbent materials
☐ General Contractor to document with photographs

I confirm the checked activities to be proceeding according to the Construction Indoor Air Quality Plan. Items that are not checked will be addressed, initialed and dated once corrective actions have been taken. Items that are not applicable are labeled as such.

Signed: ________________________________ Date: ________________
(Contractor)
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Procedures for establishing existing conditions and monitoring procedures for protection of adjacent or nearby structures and improvements including, but not limited to, sidewalks, landscaping, parking facilities, roadways, or driveways, whether on or off the University's property arising from [drilled caissons] [underpinning existing foundations] [new foundations or excavations below adjacent or nearby buildings] [sheet piling] <Insert other relevant construction operation>.

1.2 UNIVERSITY'S SURVEY

A. University has obtained visual inspections of adjacent and nearby buildings together with photographic records showing details and conditions. This survey was made on <Insert Date> and the photographs are dated and certified by the photographer as of that date. One set of these data is available for Contractor's use and records.

1.3 SUBMITTALS

A. Submit photographs and survey data from same points as original, certified and dated by photographer and taken upon completion of [pile driving] [caisson work] [underpinning existing foundations] [backfilling] <Insert relevant construction operation>.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 MONITORING

A. Establish accurate levels and positions of all elements relative to other fixed points to permit accurate monitoring of potential changes.

B. At all times during construction activities which are likely to affect adjacent properties, improvements or building, monitor conditions carefully including horizontal or vertical movements, changes in existing cracks, joints or defects or development of new cracks and other evidence of changing conditions. Report immediately to University’s Project Manager and Architect/Engineer any changes to existing conditions and stop work where such appear to be significant or potentially dangerous to persons or property.

3.2 REMEDIES
A. Conduct construction operations and specifically [excavation] [caisson drilling] [sheet piling] [underpinning] [shoring] <Insert other relevant construction operation> in a manner that will avoid damage to adjacent buildings, structures, properties or improvements. Promptly remedy any such damage whether to University's or other property and hold the University harmless from such damage.

3.3 POST-CONSTRUCTION SURVEY

A. Within 30 calendar days of completion of those construction activities that would potentially damage adjacent or nearby properties, re-survey all items of University's original survey and Contractor's supplemental information, including monitoring control points. Perform this work using a licensed surveyor and independent photographer. Identify specifically each changed condition, its magnitude and probable cause.

END OF SECTION 01 35 96
SECTION 01 40 00
QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes administrative and procedural requirements for quality assurance and quality control.
B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
1. Specific quality-assurance and -control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and -control procedures that facilitate compliance with the Contract Document requirements.
3. Requirements for Contractor to provide quality-assurance and -control services required by Architect/Engineer, University, or authorities having jurisdiction are not limited by provisions of this Section.
4. Specific test and inspection requirements are not specified in this Section.

C. Related Requirements:
1. Section 01 42 00 "Reference" for list of references, standards and definitions.
2. Section 01 91 13 “General Commissioning” for coordination of testing with commissioning activities.
3. Division 23 for testing, adjusting and balancing of mechanical systems.
4. Division 26 for testing of electrical systems.

1.3 DEFINITIONS
A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Services do not include contract enforcement activities performed by Architect/Engineer.
C. Mockups: Full-size physical assemblies that are constructed on-site. Mockups are constructed to verify selections made under Sample submittals; to demonstrate aesthetic effects and, where indicated, qualities
of materials and execution; to review coordination, testing, or operation; to show interface between dissimilar materials; and to demonstrate compliance with specified installation tolerances. Mockups are not Samples. Unless otherwise indicated, approved mockups establish the standard by which the Work will be judged.

1. As indicated in individual Specifications Sections or on the Drawings, the Work may include the following types of mockups:
   a. Laboratory Mockups: Full-size physical assemblies constructed at testing facility to verify performance characteristics.
   b. Integrated Exterior Mockups: Mockups of the exterior envelope erected separately from the building but on Project site, consisting of multiple products, assemblies, and subassemblies.
   c. Room Mockups: Mockups of typical interior spaces complete with wall, floor, and ceiling finishes, doors, windows, millwork, casework, specialties, furnishings and equipment, and lighting.

D. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria.

E. Product Testing: Tests and inspections that are performed by an NRTL, an NVLAP, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.

F. Source Quality-Control Testing: Tests and inspections that are performed at the source, e.g., plant, mill, factory, or shop.

G. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.

H. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.

I. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.

1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).

J. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.4 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Architect/Engineer for a decision before proceeding.
B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Architect/Engineer for a decision before proceeding.

1.5 ACTION SUBMITTALS

A/E note and coordinate requirement in Paragraph below to show extent of and requirement for integrated exterior mockup on Drawings.

A. Shop Drawings: Where integrated exterior mockups are required and indicated on the Drawings, provide plans, sections, and elevations, indicating materials and size of mockup construction.

1. Indicate manufacturer and model number of individual components.
2. Provide axonometric drawings for conditions difficult to illustrate in two dimensions.

1.6 INFORMATIONAL SUBMITTALS

A. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility sent to authorities having jurisdiction before starting work on the following systems:

1. Seismic-force-resisting system, designated seismic system, or component listed in the designated seismic system quality-assurance plan prepared by Architect/Engineer.

B. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

C. Schedule of Tests and Inspections: Prepare in tabular form and include the following:

1. Specification Section number and title.
2. Entity responsible for performing tests and inspections.
3. Description of test and inspection.
4. Identification of applicable standards.
5. Identification of test and inspection methods.
6. Number of tests and inspections required.
7. Time schedule or time span for tests and inspections.
8. Requirements for obtaining samples.
9. Unique characteristics of each quality-control service.

1.7 REPORTS AND DOCUMENTS

A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:

1. Date of issue.
2. Project title and number.
3. Name, address, and telephone number of testing agency.
4. Dates and locations of samples and tests or inspections.
5. Names of individuals making tests and inspections.
6. Description of the Work and test and inspection method.
8. Complete test or inspection data.
9. Test and inspection results and an interpretation of test results.
10. Record of temperature and weather conditions at time of sample taking and testing and inspectsing.
11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
12. Name and signature of laboratory inspector.
13. Recommendations on retesting and reinspectng.

B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:

1. Name, address, and telephone number of technical representative making report.
2. Statement on condition of substrates and their acceptability for installation of product.
3. Statement that products at Project site comply with requirements.
4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
5. Results of operational and other tests and a statement of whether observed performance complies with requirements.
6. Statement whether conditions, products, and installation will affect warranty.
7. Other required items indicated in individual Specification Sections.

C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:

1. Name, address, and telephone number of factory-authorized service representative making report.
2. Statement that equipment complies with requirements.
3. Results of operational and other tests and a statement of whether observed performance complies with requirements.
4. Statement whether conditions, products, and installation will affect warranty.
5. Other required items indicated in individual Specification Sections.

D. Permits, Licenses, and Certificates: For University's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.8 QUALITY ASSURANCE

A. General: Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.

1. Monitor quality control over products, services, site conditions, and workmanship to produce work of specified quality.
2. Comply fully with manufacturers' instructions, including each step in sequence.
3. If manufacturers' instructions conflict with Contract Document requirements, request clarification from Architect/Engineer before proceeding.
4. Comply with specified standards as a minimum quality for the work except when more stringent
tolerances, codes, or specified requirements indicate higher standards or more precise
workmanship.

5. Perform work by persons qualified to produce workmanship of specified quality.

B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those
indicated for this Project and with a record of successful in-service performance, as well as sufficient
production capacity to produce required units.

C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this
Project and with a record of successful in-service performance, as well as sufficient production capacity
to produce required units.

D. Subcontractor and Installer Qualifications: A firm or individual experienced in installing, erecting, or
assembling work similar in material, design, and extent to that indicated for this Project, whose work has
resulted in construction with a record of successful in-service performance. In addition comply with the
following:

1. For all trades: Proof of applicable licensing.

2. Electrical contractors:

3. Plumbing Contractors:
   c. Gas piping installations: State of Colorado master plumber with minimum 5 years
      institutional or heavy commercial gas piping experience. Provide an on-site supervisor
      with a minimum of 3 years of supervisory experience.

E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in
jurisdiction where Project is located and who is experienced in providing engineering services of the kind
indicated. Engineering services are defined as those performed for installations of the system, assembly,
or product that are similar in material, design, and extent to those indicated for this Project.

F. Specialists: Certain Specification Sections require that specific construction activities shall be performed
by entities who are recognized experts in those operations. Specialists shall satisfy qualification
requirements indicated and shall be engaged for the activities indicated.

1. Requirements of authorities having jurisdiction shall supersede requirements for specialists.

G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience
and capability to conduct testing and inspecting indicated, as documented according to ASTM E 329 or
ASTM D 3740 as appropriate; and with additional qualifications specified in individual Sections; and,
where required by authorities having jurisdiction, that is acceptable to authorities.

1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
2. NVLAP: A testing agency accredited according to NIST’s National Voluntary Laboratory
   Accreditation Program.
3. Independent Agency: Meeting “Recommended Requirements for Independent Laboratory
   Qualifications” published by American Council for Independent Laboratories.
4. Authorized to operate in the State of Colorado.
5. Calibrate testing equipment at reasonable intervals with devices of accuracy traceable to National Bureau of Standards or of accepted values of natural physical constants.

H. Manufacturer's Technical Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

I. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

J. Preconstruction Testing: Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:

1. Contractor responsibilities include the following:
   a. Provide test specimens representative of proposed products and construction.
   b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
   c. Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
   d. When required, build site-assembled test assemblies and mockups using installers who will perform same tasks for Project.
   e. When required, build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
   f. When testing is complete, remove test specimens, assemblies, mockups, and laboratory mockups, as applicable; do not reuse products on Project.

2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Architect/Engineer, with copy to Contractor. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.

K. Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:

1. Build mockups in location and of size indicated or, if not indicated, as directed by Architect/Engineer.
2. Notify Architect/Engineer seven calendar days in advance of dates and times when mockups will be constructed.
3. Employ supervisory personnel who will oversee mockup construction. Employ workers that will be employed during the construction at Project.
4. Demonstrate the proposed range of aesthetic effects and workmanship.
5. Obtain Architect/Engineer's approval of mockups before starting work, fabrication, or construction.
   a. Allow seven calendar days for initial review and each re-review of each mockup.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed unless otherwise indicated.
L. Integrated Exterior Mockups: When indicated on Drawings, construct integrated exterior mockup. Coordinate installation of exterior envelope materials and products for which mockups are required in individual Specification Sections, along with supporting materials.

M. Room Mockups: When indicated on Drawings, construct room mockups incorporating required materials and assemblies, finished according to requirements. Provide required lighting and additional lighting where required to enable Architect/Engineer to evaluate quality of the Work. Provide room mockups of the following rooms:

N. Laboratory Mockups: When required by individual Specification Sections, comply with requirements of preconstruction testing and those specified in individual Specification Sections.

1.9 QUALITY CONTROL

A. University Responsibilities: Where quality-control services are indicated as University's responsibility, University will engage a qualified testing agency to perform these services.

1. University will furnish Contractor with names, addresses, and telephone numbers of testing agencies engaged and a description of types of testing and inspecting they are engaged to perform.
2. Payment for these services will be made by the University.
3. Costs for retesting and reinspecting construction that replaces or is necessitated by work that failed to comply with the Contract Documents will be charged to Contractor.

B. Contractor Responsibilities: Tests and inspections not explicitly assigned to University are Contractor's responsibility. Perform additional quality-control activities required to verify that the Work complies with requirements, whether specified or not.

1. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.
2. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality-control services.
   a. Contractor shall not employ same entity engaged by University, unless agreed to in writing by University.
3. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspecting will be performed.
4. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
5. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
6. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

C. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 01 33 00 "Submittal Procedures."

D. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in preinstallation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.
E. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.

   1. Notify Architect/Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during its services.
   2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
   3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
   4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
   5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
   6. Do not perform any duties of Contractor.

G. Associated Services: Cooperate with agencies performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
   1. Access to the Work.
   2. Incidental labor and facilities necessary to facilitate tests and inspections.
   3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
   4. Facilities for storage and field curing of test samples including, but not limited to, safe storage and proper curing of concrete test cylinders at Project site for first 24 hours after casting as required by ASTM C 31.
   5. Delivery of samples to testing agencies.
   6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
   7. Security and protection for samples and for testing and inspecting equipment at Project site.

H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
   1. Schedule times for tests, inspections, obtaining samples, and similar activities.

I. Manufactured Items and Equipment: Where manufactured products or equipment are required to have representative samples tested, do not use such materials or equipment until tests have been made and the materials or equipment found to be acceptable. Do not incorporate in the work any product which becomes unfit for use after acceptance.

J. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents. Coordinate and submit concurrently with Contractor's construction schedule. Update as the Work progresses.
   1. Distribution: Distribute schedule to University, Architect/Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.
1.10 SPECIAL TESTS AND INSPECTIONS

A. Special Tests and Inspections: University will engage a qualified testing agency or special inspector to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of University, and as follows:

1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviews the completeness and adequacy of those procedures to perform the Work.
2. Notifying Architect/Engineer and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
3. Submitting a certified written report of each test, inspection, and similar quality-control service to Architect/Engineer with copy to Contractor and to authorities having jurisdiction.
4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
6. Retesting and reinspecting corrected work.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TEST AND INSPECTION LOG

A. Test and Inspection Log: Prepare a record of tests and inspections including instructions received from University. Include the following:

1. Date test or inspection was conducted.
2. Description of the Work tested or inspected.
3. Date test or inspection results were transmitted to Architect/Engineer.
4. Identification of testing agency or special inspector conducting test or inspection.
5. Disposition: Pass, fail, nature of defects, if any.
6. Date and descriptions of remedial or correction action taken.

B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Architect/Engineer's reference during normal working hours.

3.2 REPAIR AND PROTECTION

A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.

1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 01 73 00 "Execution."

B. Protect construction exposed by or for quality-control service activities.

C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.
3.3 SCHEDULE OF INSPECTIONS AND TESTS BY UNIVERSITY

A. University will engage testing agency and pay for testing and inspection associated with the following materials and systems, where included in the Project:

1. Compaction density of fill and backfill.
2. Drilled pier end bearing conditions and depths.
4. Precast concrete.
5. Post-tensioned concrete tendons.
7. Structural steel field welds and bolted connections.
8. Spray-applied fireproofing.
10. Asphalitic concrete paving.
11. Foundation drainage systems.
12. Drainage structures and piping.
15. Fluid applied membranes.
16. Thermal imaging.
17. Curtain wall, window, and door field testing.
18. Ceiling hanger wire pull-out.
20. Field sound testing of operable partitions.
22. Fan vibration.

END OF SECTION 01 40 00
SECTION 01 41 00

REGULATORY REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Building Department Authority.
2. MS 4 Storm Water and Water Quality Permits
3. Applicable Codes and Standards.

1.3 BUILDING DEPARTMENT AUTHORITY

A. The University of Colorado Denver is charged with the responsibility of ensuring that provision of applicable codes, standards and guidelines are met on its campuses.

B. The University Denver campus has an established Building Authority responsible to review and examine buildings and plan documents, to permit and inspect construction and/or demolition to ensure conformance to codes adopted by the University and issue certificates of temporary occupancy and occupancy if satisfactory conformance is demonstrated.

C. The authority is executed by the Campus Building Official (CBO) who has the responsibility to perform all the duties set forth in the Current Approved State Buildings Codes and other applicable codes and standards indicated in the “Applicable Codes and Standards” Article of this Section.

D. Permits: Obtain a separate permit for each Project from the Office of the CBO prior to erecting, constructing, enlarging, repairing, moving, removing, converting or demolishing any building or portion thereof. Coordinate and obtain all permits through the University Project Manager. The Contractor is not responsible for costs associated with construction permits.

1. Exempt work: A building permit is not required for the following:

   a. Fences less than or equal to 6 feet tall.
   b. Movable casework, counters and partitions not over 5 feet 9 inches tall with no electrical or plumbing.
   c. Platforms, walks, and driveways not more than 30 inches above grade and not over any basement or story below.
   d. Painting, papering and similar finish work.
   e. Other work of limited scope at the discretion of the CBO.

E. Permit Issuance: The CBO, or at the discretion of the CBO a third party code consultant, will review application, Drawings, Specifications, computations and other data filed for permit. Complete the permit
application with the University Project Manager. Permits require submittal of two (2) stamped, signed sets of Construction Documents, including Drawings, Specifications and all Addenda, and one (1) set of each engineering discipline’s calculations, where such calculations are required. If CBO determines that submittal conforms to the requirements of the Building Code and other applicable codes, standards, laws, regulations and ordinances, an inspection record card will be issued with the building permit. Keep one stamped set of documents on site. The University will keep one stamped set in the Campus Support plan room.

F. Suspension or Revocation of Permit: CBO may, in writing, suspend or revoke a permit issued in error or on the basis of submitted information that is incorrect or that is in violation of the Building Code and other applicable codes and standards.

G. Posting of Permit: Post the Permit in a visible and protected location near the access to the project.

H. Inspection Record Card: Post the Inspection Record Card next to the permit in a visible and protected location near the access to the project. CBO will make required entries based on inspection of the work.

I. Inspection Requests:
   1. Notify CBO that work is ready for inspection two business days before such inspection is desired by telephoning the number posted on the permit. The CBO retains the right to require requests in writing.
   2. A re-inspection fee may be charged for prior rejected items.

J. Construction Inspections:
   1. Contractor is not responsible for costs associated with construction inspections, except re-inspections. The CBO or his/her designee will perform all general building, electrical and plumbing inspections. All construction or work for which a permit is required must remain accessible and exposed for inspection purposes. Provide access to and means for inspection of work.
   2. Site Utilities: Contact and comply with all requirements of City and County of Denver for site utility inspections.
   3. Plumbing and Electrical Inspections: For new buildings and major additions, contact and comply with all requirements of State of Colorado Plumbing and Electrical Boards.
   4. Provisions for structural and other special inspections required by Contract Documents, current approved State Building Codes and University Codes will be provided by the University.

K. Certification of Occupancy:
   1. When CBO inspects the project and finds no violations of any provision of the Building Code, other applicable codes, standards, laws, regulations and ordinances, CBO will issue a Certification of Occupancy (CO) which will contain the following:
      a. Building permit number.
      b. Address of building.
      c. Name and address of Owner.
      d. Description of building or portion thereof for which certification is issued.
      e. Statement that described building or portion thereof has been inspected for compliance with the requirements of the Building Code, other applicable codes, standards, laws, regulations and ordinances, as relates to type of occupancy and use for which the building is intended.
2. Temporary Certificate of Occupancy (TCO): If CBO finds no substantial hazard will result from occupancy of any building or portion thereof before the same is completed, CBO may issue a TCO for the use of a portion or portions of a building or structure prior to the completion of the entire building or structure.

3. Posting of CO: Provide a copy to the University Project Manager and post in a conspicuous location on the premises. CO may not be removed except by CBO upon initial occupancy.

4. Revocation of CO:

1.4 MS4 STORM WATER AND WATER QUALITY PERMITS

A. Obtain necessary State of Colorado and City and County of Denver Permits to the extent that Project impacts site.

1.5 APPLICABLE CODES AND STANDARDS

A. The following approved building codes and standards have been adopted by State Buildings Programs (SBP) as the minimum requirements to be applied to all state-owned buildings and physical facilities including capital construction and controlled maintenance construction projects. Current applicable codes can be obtained from The Office of the State Architect’s website.

B. University of Colorado Denver Codes and Standards: The following codes and standards supplement those indicated on the Office of the State Architect website.


   a. Use the most restrictive interpretation where NFPA 101 conflicts with the IBC requirements.


17. OSHA “Safety and Health Regulation for Construction” (29 CFR 1926).
21. CDC-NIH Biosafety in Microbiological and Biomedical Laboratories (BMBL); latest edition.


C. Other Standards: As indicated in individual Specification Sections.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 41 00
SECTION 01 42 00

REFERENCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Definitions.
   2. Industry Standards.
   3. Abbreviations and Acronyms.

B. Related Requirements:
   1. Section 01 10 00 “Summary” for an explanation of specification and drawing conventions.
   2. Section 01 41 00 “Regulatory Requirements” for a list of applicable codes.

1.3 DEFINITIONS

A. General: Basic Contract definitions are included in the Conditions of the Contract.
   1. Definitions in this Section are not intended to be complete, exhaustive or exclusive. They are general and apply to the Work to the extent that such definitions are not stated more explicitly in other provisions of the Contract Documents.

B. "Approved": When used to convey Architect/Engineer's action on Contractor's submittals, applications, and requests, "approved" is limited to Architect/Engineer's duties and responsibilities as stated in the Conditions of the Contract. Except where expressly indicated, such approval does not release the Contractor from responsibility to fulfill requirements of the Contract Documents.

C. “Backup”: N+1 system.

D. "Directed": A command or instruction by Architect/Engineer. Other terms including "requested," "authorized," "selected," "required," and "permitted" have the same meaning as "directed."

E. “EHS”: Environmental Health and Safety.

F. “Engineer”: Architect/Engineer. Other terms including “Mechanical Engineer”, “Electrical Engineer”, or “Structural Engineer” have the same meaning as “Engineer.”

In Paragraph below select appropriate option based on Project delivery method.
G. “General Conditions”: Contract terms contained in [Contractor’s Agreement Design/Bid/Build, State Form SC-6.21 and The General Conditions of the Construction Contract Design/Bid/Build, State Form SC-6.23] [Construction Manager/General Contractor Agreement CMGC, State Form SC-6.4] [Design/Build Agreement, State Form SC-8.0 and The General Conditions of the Design/Build Agreement, State Form SC-8.1]

H. “General Requirements”: Provisions and requirements of all Division 01 Sections as they apply to all aspects of the Work.

I. “Guarantee”: The narrow definition of the term “warranty” applying to both “warranty” and “guarantee” which terms are used interchangeably.

J. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."

K. “Redundant”: 2N system. The level of redundancy is determined by design.

L. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work, whether lawfully imposed by authorities having jurisdiction or not.

M. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

N. "Install": Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

O. “Owner”: Principal Representative and/or University.

P. "Provide": Furnish and install, complete and ready for the intended use.

Q. “Project Manual”: Bound, printed volume or volumes including Conditions of the Contract and Specifications, which may also include bidding requirements, contract forms, details, schedules, surveys, reports or other relevant items that may or may not be Contract Documents.

R. "Project Site": Space available for performing construction activities, either exclusively or in conjunction with others performing other work as part of the Project. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.

S. “Supplementary Conditions”: University Special Supplementary General Conditions. Other terms including “Supplementary General Conditions” shall have the same meaning.

1.4 INDUSTRY STANDARDS

A. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

1. Referenced standards take precedence over standards that are not referenced but generally recognized in the construction industry as applicable.
B. Publication Dates: Comply with standards in effect as of date of the Contract Documents.

1. Updated Codes and Standards: Where an applicable code or standard has been revised and reissued after the date of the Contract Documents and before performance of Work affected, submit Contractor-Initiated Change Order Bulletin and Change Order Proposal in accordance with Section 01 26 00 “Contract Modification Procedures” for consideration to modify contract requirements to comply with revised code or standard.

C. Copies of Standards: Each entity engaged in construction on Project should be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.

1. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source.
2. Where required by individual Specification Sections provide and maintain copies of referenced codes and standards at Project Site.
3. Although copies of standards needed for enforcement of requirements may be part of required submittals, the Architect/Engineer reserves the right to require the Contractor to submit additional copies as necessary for enforcement of requirements.

D. Unreferenced Standards: Unreferenced standards are not directly applicable to the Work, except as a general requirement of whether the Work complies with recognized construction industry standards.

E. Conflicting Requirements: Where compliance with two or more standards is specified, and they establish different or conflicting requirements for minimum quantities or quality levels, the most stringent requirement will be enforced, unless the Contract Documents indicate otherwise. Refer requirements that are different, but apparently equal, and uncertainties as to which quality level is more stringent to the Architect/Engineer for a decision before proceeding.

1.5 ABBREVIATIONS AND ACRONYMS

A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Name</th>
<th>Phone</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>AABC</td>
<td>Associated Air Balance Council</td>
<td>(202) 737-0202</td>
<td><a href="http://www.aabc.com">www.aabc.com</a></td>
</tr>
<tr>
<td>AAMA</td>
<td>American Architectural Manufacturers Association</td>
<td>(847) 303-5664</td>
<td><a href="http://www.aamanet.org">www.aamanet.org</a></td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
<td>(202) 624-5800</td>
<td><a href="http://www.transportation.org">www.transportation.org</a></td>
</tr>
<tr>
<td>AATCC</td>
<td>American Association of Textile Chemists and Colorists</td>
<td>(919) 549-8141</td>
<td><a href="http://www.aatcc.org">www.aatcc.org</a></td>
</tr>
<tr>
<td>ABMA</td>
<td>American Bearing Manufacturers Association</td>
<td>(202) 367-1155</td>
<td><a href="http://www.americanbearings.org">www.americanbearings.org</a></td>
</tr>
<tr>
<td>ACI</td>
<td>American Concrete Institute</td>
<td>(248) 848-3700</td>
<td><a href="http://www.concrete.org">www.concrete.org</a></td>
</tr>
</tbody>
</table>
ACPA
American Concrete Pipe Association
www.concrete-pipe.org
(972) 506-7216

AEIC
Association of Edison Illuminating Companies, Inc. (The)
www.aeic.org
(205) 257-2530

AF&PA
American Forest & Paper Association
www.afandpa.org
(800) 878-8878
(202) 463-2700

AGA
American Gas Association
www.aga.org
(202) 824-7000

AHAM
Association of Home Appliance Manufacturers
www.aham.org
(202) 872-5955

AHRI
Air-Conditioning, Heating, and Refrigeration Institute (The)
www.ahrinet.org
(703) 524-8800

AI
Asphalt Institute
www.asphaltinstitute.org
(859) 288-4960

AIA
American Institute of Architects (The)
www.aia.org
(800) 242-3837
(202) 626-7300

AISC
American Institute of Steel Construction
www.aisc.org
(800) 644-2400
(312) 670-2400

AISI
American Iron and Steel Institute
www.steel.org
(202) 452-7100

AITC
American Institute of Timber Construction
www.aitc-glulam.org
(303) 792-9559

AMCA
Air Movement and Control Association International, Inc.
www.amca.org
(847) 394-0150

ANSI
American National Standards Institute
www.ansi.org
(202) 293-8020

AOSA
Association of Official Seed Analysts, Inc.
www.aosaseed.com
(607) 256-3313

APA
APA - The Engineered Wood Association
www.apawood.org
(253) 565-6600

APA
Architectural Precast Association
www.archprecast.org
(239) 454-6989

API
American Petroleum Institute
www.api.org
(202) 682-8000

ARI
Air-Conditioning & Refrigeration Institute
(See AHRI)
REFERENCES

ARI  American Refrigeration Institute
      (See AHRI)

ARMA  Asphalt Roofing Manufacturers Association
       www.asphaltroofing.org

ASCE  American Society of Civil Engineers
       www.asce.org

ASCE/SEI  American Society of Civil Engineers/Structural Engineering Institute
          (See ASCE)

ASHRAE  American Society of Heating, Refrigerating and Air-Conditioning Engineers
        www.ashrae.org

ASME  ASME International
       (American Society of Mechanical Engineers)
       www.asme.org

ASSE  American Society of Safety Engineers (The)
       www.asse.org

ASSE  American Society of Sanitary Engineering
       www.asse-plumbing.org

ASTM  ASTM International
      (American Society for Testing and Materials International)
      www.astm.org

ATIS  Alliance for Telecommunications Industry Solutions
       www.atis.org

AWEA  American Wind Energy Association
       www.awea.org

AWI  Architectural Woodwork Institute
      www.awinet.org

AWMAC  Architectural Woodwork Manufacturers Association of Canada
        www.awmac.com

AWPA  American Wood Protection Association
       (Formerly:  American Wood-Preservers' Association)
       www.awpa.com

AWS  American Welding Society
     www.aws.org

AWWA  American Water Works Association
       www.awwa.org

BHMA  Builders Hardware Manufacturers Association
       www.buildershardware.com

REFERENCES
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>Phone Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIA</td>
<td>Brick Industry Association (The)</td>
<td>(703) 620-0010</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.gobrick.com">www.gobrick.com</a></td>
<td></td>
</tr>
<tr>
<td>BICSI</td>
<td>BICSI, Inc.</td>
<td>(800) 242-7405</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.bicsi.org">www.bicsi.org</a></td>
<td>(813) 979-1991</td>
</tr>
<tr>
<td>BIFMA</td>
<td>BIFMA International (Business and Institutional Furniture Manufacturer's Association)</td>
<td>(616) 285-3963</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.bifma.com">www.bifma.com</a></td>
<td></td>
</tr>
<tr>
<td>BISSC</td>
<td>Baking Industry Sanitation Standards Committee</td>
<td>(866) 342-4772</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.bissc.org">www.bissc.org</a></td>
<td></td>
</tr>
<tr>
<td>BOCA</td>
<td>BOCA (Building Officials and Code Administrators International Inc.) (See ICC)</td>
<td></td>
</tr>
<tr>
<td>BWF</td>
<td>Badminton World Federation (Formerly: International Badminton Federation)</td>
<td>60 3 9283 7155</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.bwfbadminton.org">www.bwfbadminton.org</a></td>
<td></td>
</tr>
<tr>
<td>CDA</td>
<td>Copper Development Association</td>
<td>(800) 232-3282</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.copper.org">www.copper.org</a></td>
<td>(212) 251-7200</td>
</tr>
<tr>
<td>CEA</td>
<td>Canadian Electricity Association</td>
<td>(613) 230-9263</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.electricity.ca">www.electricity.ca</a></td>
<td></td>
</tr>
<tr>
<td>CEA</td>
<td>Consumer Electronics Association</td>
<td>(866) 858-1555</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.ce.org">www.ce.org</a></td>
<td>(703) 907-7600</td>
</tr>
<tr>
<td>CFFA</td>
<td>Chemical Fabrics &amp; Film Association, Inc.</td>
<td>(216) 241-7333</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.chemicalfabricsandfilm.com">www.chemicalfabricsandfilm.com</a></td>
<td></td>
</tr>
<tr>
<td>CFSEI</td>
<td>Cold-Formed Steel Engineers Institute</td>
<td>(866) 465-4732</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cfsei.org">www.cfsei.org</a></td>
<td>(202) 263-4488</td>
</tr>
<tr>
<td>CGA</td>
<td>Compressed Gas Association</td>
<td>(703) 788-2700</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cganet.com">www.cganet.com</a></td>
<td></td>
</tr>
<tr>
<td>CIMA</td>
<td>Cellulose Insulation Manufacturers Association</td>
<td>(888) 881-2462</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cellulose.org">www.cellulose.org</a></td>
<td>(937) 222-2462</td>
</tr>
<tr>
<td>CISCA</td>
<td>Ceilings &amp; Interior Systems Construction Association</td>
<td>(630) 584-1919</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cisca.org">www.cisca.org</a></td>
<td></td>
</tr>
<tr>
<td>CISPI</td>
<td>Cast Iron Soil Pipe Institute</td>
<td>(404) 622-0073</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cispi.org">www.cispi.org</a></td>
<td></td>
</tr>
<tr>
<td>CLFMI</td>
<td>Chain Link Fence Manufacturers Institute</td>
<td>(301) 596-2583</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.chainlinkinfo.org">www.chainlinkinfo.org</a></td>
<td></td>
</tr>
<tr>
<td>CPA</td>
<td>Composite Panel Association</td>
<td>(703) 724-1128</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.pbmdf.com">www.pbmdf.com</a></td>
<td></td>
</tr>
<tr>
<td>CRI</td>
<td>Carpet and Rug Institute (The)</td>
<td>(706) 278-3176</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.carpet-rug.org">www.carpet-rug.org</a></td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES
### REFERENCES

<table>
<thead>
<tr>
<th>Organization</th>
<th>Address</th>
<th>Phone Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRRC</td>
<td>Cool Roof Rating Council</td>
<td>(866) 465-2523</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.coolroofs.org">www.coolroofs.org</a></td>
<td>(510) 485-7175</td>
</tr>
<tr>
<td>CRSI</td>
<td>Concrete Reinforcing Steel Institute</td>
<td>(800) 328-6306</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.crsi.org">www.crsi.org</a></td>
<td>(847) 517-1200</td>
</tr>
<tr>
<td>CSA</td>
<td>Canadian Standards Association</td>
<td>(800) 463-6727</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.csa.ca">www.csa.ca</a></td>
<td>(416) 747-4000</td>
</tr>
<tr>
<td>CSA</td>
<td>CSA International</td>
<td>(866) 797-4272</td>
</tr>
<tr>
<td></td>
<td>(Formerly: IAS - International Approval Services)</td>
<td>(416) 747-4000</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.csa-international.org">www.csa-international.org</a></td>
<td></td>
</tr>
<tr>
<td>CSI</td>
<td>Construction Specifications Institute (The)</td>
<td>(800) 689-2900</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.csinet.org">www.csinet.org</a></td>
<td>(703) 684-0300</td>
</tr>
<tr>
<td>CSSB</td>
<td>Cedar Shake &amp; Shingle Bureau</td>
<td>(604) 820-7700</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cedarbureau.org">www.cedarbureau.org</a></td>
<td></td>
</tr>
<tr>
<td>CTI</td>
<td>Cooling Technology Institute</td>
<td>(281) 583-4087</td>
</tr>
<tr>
<td></td>
<td>(Formerly: Cooling Tower Institute)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="http://www.cti.org">www.cti.org</a></td>
<td></td>
</tr>
<tr>
<td>CWC</td>
<td>Composite Wood Council</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(See CPA)</td>
<td></td>
</tr>
<tr>
<td>DASMA</td>
<td>Door and Access Systems Manufacturers Association</td>
<td>(216) 241-7333</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.dasma.com">www.dasma.com</a></td>
<td></td>
</tr>
<tr>
<td>DHI</td>
<td>Door and Hardware Institute</td>
<td>(703) 222-2010</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.dhi.org">www.dhi.org</a></td>
<td></td>
</tr>
<tr>
<td>ECA</td>
<td>Electronic Components Association</td>
<td>(703) 907-8024</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.ec-central.org">www.ec-central.org</a></td>
<td></td>
</tr>
<tr>
<td>ECAMA</td>
<td>Electronic Components Assemblies &amp; Materials Association</td>
<td>(See ECA)</td>
</tr>
<tr>
<td>EIA</td>
<td>Electronic Industries Alliance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(See TIA)</td>
<td></td>
</tr>
<tr>
<td>EIMA</td>
<td>EIFS Industry Members Association</td>
<td>(800) 294-3462</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.eima.com">www.eima.com</a></td>
<td>(703) 538-1616</td>
</tr>
<tr>
<td>EJMA</td>
<td>Expansion Joint Manufacturers Association, Inc.</td>
<td>(914) 332-0040</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.ejma.org">www.ejma.org</a></td>
<td></td>
</tr>
<tr>
<td>ESD</td>
<td>ESD Association</td>
<td>(315) 339-6937</td>
</tr>
<tr>
<td></td>
<td>(Electrostatic Discharge Association)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><a href="http://www.esda.org">www.esda.org</a></td>
<td></td>
</tr>
<tr>
<td>ESTA</td>
<td>Entertainment Services and Technology Association</td>
<td>(See PLASA)</td>
</tr>
<tr>
<td>Acronym</td>
<td>Name</td>
<td>Phone Numbers</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>--------------</td>
</tr>
<tr>
<td>EVO</td>
<td>Efficiency Valuation Organization</td>
<td>(415) 367-3643 44 20 88 167 857</td>
</tr>
<tr>
<td>FIBA</td>
<td>Fédération Internationale de Basketball (The International Basketball Federation)</td>
<td>41 22 545 00 00</td>
</tr>
<tr>
<td>FIVB</td>
<td>Fédération Internationale de Volleyball (The International Volleyball Federation)</td>
<td>41 21 345 35 45</td>
</tr>
<tr>
<td>FM Approvals</td>
<td>FM Approvals LLC</td>
<td>(781) 762-4300</td>
</tr>
<tr>
<td>FM Global</td>
<td>FM Global (Formerly: FMG - FM Global)</td>
<td>(401) 275-3000</td>
</tr>
<tr>
<td>FRSA</td>
<td>Florida Roofing, Sheet Metal &amp; Air Conditioning Contractors Association, Inc.</td>
<td>(407) 671-3772</td>
</tr>
<tr>
<td>FSA</td>
<td>Fluid Sealing Association</td>
<td>(610) 971-4850</td>
</tr>
<tr>
<td>FSC</td>
<td>Forest Stewardship Council U.S.</td>
<td>(612) 353-4511</td>
</tr>
<tr>
<td>GA</td>
<td>Gypsum Association</td>
<td>(301) 277-8686</td>
</tr>
<tr>
<td>GANA</td>
<td>Glass Association of North America</td>
<td>(785) 271-0208</td>
</tr>
<tr>
<td>GS</td>
<td>Green Seal</td>
<td>(202) 872-6400</td>
</tr>
<tr>
<td>HI</td>
<td>Hydraulic Institute</td>
<td>(973) 267-9700</td>
</tr>
<tr>
<td>HI/GAMA</td>
<td>Hydronics Institute/Gas Appliance Manufacturers Association (See AHRI)</td>
<td></td>
</tr>
<tr>
<td>HMMA</td>
<td>Hollow Metal Manufacturers Association (See NAAMM)</td>
<td></td>
</tr>
<tr>
<td>HPVA</td>
<td>Hardwood Plywood &amp; Veneer Association</td>
<td>(703) 435-2900</td>
</tr>
<tr>
<td>HPW</td>
<td>H. P. White Laboratory, Inc.</td>
<td>(410) 838-6550</td>
</tr>
<tr>
<td>IAPSC</td>
<td>International Association of Professional Security Consultants</td>
<td>(415) 536-0288</td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Name</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td>IAS</td>
<td>International Approval Services</td>
<td>(See CSA)</td>
</tr>
<tr>
<td>ICBO</td>
<td>International Conference of Building Officials</td>
<td>(See ICC)</td>
</tr>
<tr>
<td>ICC</td>
<td>International Code Council</td>
<td></td>
</tr>
<tr>
<td>ICEA</td>
<td>Insulated Cable Engineers Association, Inc.</td>
<td></td>
</tr>
<tr>
<td>ICPA</td>
<td>International Cast Polymer Alliance</td>
<td></td>
</tr>
<tr>
<td>ICRI</td>
<td>International Concrete Repair Institute, Inc.</td>
<td></td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
<td></td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers, Inc. (The)</td>
<td></td>
</tr>
<tr>
<td>IES</td>
<td>Illuminating Engineering Society</td>
<td>(Formerly: Illuminating Engineering Society of North America)</td>
</tr>
<tr>
<td>IESNA</td>
<td>Illuminating Engineering Society of North America</td>
<td>(See IES)</td>
</tr>
<tr>
<td>IEST</td>
<td>Institute of Environmental Sciences and Technology</td>
<td></td>
</tr>
<tr>
<td>IGMA</td>
<td>Insulating Glass Manufacturers Alliance</td>
<td></td>
</tr>
<tr>
<td>IGSHPA</td>
<td>International Ground Source Heat Pump Association</td>
<td></td>
</tr>
<tr>
<td>ILI</td>
<td>Indiana Limestone Institute of America, Inc.</td>
<td></td>
</tr>
<tr>
<td>Intertek</td>
<td>Intertek Group</td>
<td>(Formerly: ETL SEMCO; Intertek Testing Service NA)</td>
</tr>
<tr>
<td>ISA</td>
<td>International Society of Automation (The)</td>
<td>(Formerly: Instrumentation, Systems, and Automation Society)</td>
</tr>
<tr>
<td>ISAS</td>
<td>Instrumentation, Systems, and Automation Society (The)</td>
<td>(See ISA)</td>
</tr>
</tbody>
</table>
ISFA  International Surface Fabricators Association
(Formerly: International Solid Surface Fabricators Association)
www.isfanow.org

ISO  International Organization for Standardization
www.iso.org

ISSFA  International Solid Surface Fabricators Association
(See ISFA)

ITU  International Telecommunication Union
www.itu.int/home

KCMA  Kitchen Cabinet Manufacturers Association
www.kcma.org

LMA  Laminating Materials Association
(See CPA)

LPI  Lightning Protection Institute
www.lightning.org

MBMA  Metal Building Manufacturers Association
www.mbma.com

MCA  Metal Construction Association
www.metalconstruction.org

MFMA  Maple Flooring Manufacturers Association, Inc.
www.maplefloor.org

MFMA  Metal Framing Manufacturers Association, Inc.
www.metalframingmfg.org

MHIA  Material Handling Industry of America
www.mhia.org

MIA  Marble Institute of America
www.marble-institute.com

MMPA  Moulding & Millwork Producers Association
(Formerly: Wood Moulding & Millwork Producers Association)
www.wmmpa.com

MPI  Master Painters Institute
www.paintinfo.com

MSS  Manufacturers Standardization Society of The Valve and Fittings Industry Inc.
www.mss-hq.org

NAAMM  National Association of Architectural Metal Manufacturers
www.naamm.org

REFERENCES
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>Phone Numbers</th>
<th>Website Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>NACE</td>
<td>NACE International (National Association of Corrosion Engineers International)</td>
<td>(800) 797-6223, (281) 228-6200</td>
<td><a href="http://www.nace.org">www.nace.org</a></td>
</tr>
<tr>
<td>NADCA</td>
<td>National Air Duct Cleaners Association</td>
<td>(202) 737-2926</td>
<td><a href="http://www.nadca.com">www.nadca.com</a></td>
</tr>
<tr>
<td>NAIMA</td>
<td>North American Insulation Manufacturers Association</td>
<td>(703) 684-0084</td>
<td><a href="http://www.naima.org">www.naima.org</a></td>
</tr>
<tr>
<td>NBGQA</td>
<td>National Building Granite Quarries Association, Inc.</td>
<td>(800) 557-2848</td>
<td><a href="http://www.nbgqa.com">www.nbgqa.com</a></td>
</tr>
<tr>
<td>NCAA</td>
<td>National Collegiate Athletic Association (The)</td>
<td>(317) 917-6222</td>
<td><a href="http://www.ncaa.org">www.ncaa.org</a></td>
</tr>
<tr>
<td>NCMA</td>
<td>National Concrete Masonry Association</td>
<td>(703) 713-1900</td>
<td><a href="http://www.ncma.org">www.ncma.org</a></td>
</tr>
<tr>
<td>NEBB</td>
<td>National Environmental Balancing Bureau</td>
<td>(301) 977-3698</td>
<td><a href="http://www.nebb.org">www.nebb.org</a></td>
</tr>
<tr>
<td>NECA</td>
<td>National Electrical Contractors Association</td>
<td>(301) 657-3110</td>
<td><a href="http://www.necanet.org">www.necanet.org</a></td>
</tr>
<tr>
<td>NeLMA</td>
<td>Northeastern Lumber Manufacturers Association</td>
<td>(207) 829-6901</td>
<td><a href="http://www.nelma.org">www.nelma.org</a></td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
<td>(703) 841-3200</td>
<td><a href="http://www.nema.org">www.nema.org</a></td>
</tr>
<tr>
<td>NETA</td>
<td>InterNational Electrical Testing Association</td>
<td>(888) 300-6382, (269) 488-6382</td>
<td><a href="http://www.netaworld.org">www.netaworld.org</a></td>
</tr>
<tr>
<td>NFHS</td>
<td>National Federation of State High School Associations</td>
<td>(317) 972-6900</td>
<td><a href="http://www.nfhs.org">www.nfhs.org</a></td>
</tr>
<tr>
<td>NFPA</td>
<td>NFPA (National Fire Protection Association)</td>
<td>(800) 344-3555, (617) 770-3000</td>
<td><a href="http://www.nfpa.org">www.nfpa.org</a></td>
</tr>
<tr>
<td>NFPA</td>
<td>NFPA International</td>
<td>(301) 589-1776</td>
<td><a href="http://www.nfrc.org">www.nfrc.org</a></td>
</tr>
<tr>
<td>NFRC</td>
<td>National Fenestration Rating Council</td>
<td>(301) 589-1776</td>
<td><a href="http://www.nfrc.org">www.nfrc.org</a></td>
</tr>
<tr>
<td>NHLA</td>
<td>National Hardwood Lumber Association</td>
<td>(800) 933-0318, (901) 377-1818</td>
<td><a href="http://www.nhla.com">www.nhla.com</a></td>
</tr>
<tr>
<td>NLGA</td>
<td>National Lumber Grades Authority</td>
<td>(604) 524-2393</td>
<td><a href="http://www.nlga.org">www.nlga.org</a></td>
</tr>
<tr>
<td>NOFMA</td>
<td>National Oak Flooring Manufacturers Association</td>
<td>(317) 972-6900</td>
<td><a href="http://www.nlga.org">www.nlga.org</a></td>
</tr>
</tbody>
</table>

REFERENCES
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMMA</td>
<td>National Ornamental &amp; Miscellaneous Metals Association</td>
<td>(888) 516-8585</td>
</tr>
<tr>
<td>NRCA</td>
<td>National Roofing Contractors Association</td>
<td>(800) 323-9545, (847) 299-9070</td>
</tr>
<tr>
<td>NRMCA</td>
<td>National Ready Mixed Concrete Association</td>
<td>(888) 846-7622, (301) 587-1400</td>
</tr>
<tr>
<td>NSF</td>
<td>NSF International (National Sanitation Foundation International)</td>
<td>(800) 673-6275, (734) 769-8010</td>
</tr>
<tr>
<td>NSPE</td>
<td>National Society of Professional Engineers</td>
<td>(703) 684-2800</td>
</tr>
<tr>
<td>NSSGA</td>
<td>National Stone, Sand &amp; Gravel Association</td>
<td>(800) 342-1415, (703) 525-8788</td>
</tr>
<tr>
<td>NTMA</td>
<td>National Terrazzo &amp; Mosaic Association, Inc. (The)</td>
<td>(800) 323-9736</td>
</tr>
<tr>
<td>NWFA</td>
<td>National Wood Flooring Association</td>
<td>(800) 422-4556, (636) 519-9663</td>
</tr>
<tr>
<td>PCI</td>
<td>Precast/Prestressed Concrete Institute</td>
<td>(312) 786-0300</td>
</tr>
<tr>
<td>PDI</td>
<td>Plumbing &amp; Drainage Institute</td>
<td>(800) 589-8956, (978) 557-0720</td>
</tr>
<tr>
<td>PLASA</td>
<td>PLASA (Formerly: ESTA - Entertainment Services and Technology Association)</td>
<td>(212) 244-1505</td>
</tr>
<tr>
<td>RCSC</td>
<td>Research Council on Structural Connections</td>
<td><a href="http://www.boltcouncil.org">www.boltcouncil.org</a></td>
</tr>
<tr>
<td>RFCI</td>
<td>Resilient Floor Covering Institute</td>
<td>(706) 882-3833</td>
</tr>
<tr>
<td>RIS</td>
<td>Redwood Inspection Service</td>
<td>(925) 935-1499</td>
</tr>
<tr>
<td>SAE</td>
<td>SAE International (Society of Automotive Engineers)</td>
<td>(877) 606-7323, (724) 776-4841</td>
</tr>
<tr>
<td>SBCCI</td>
<td>Southern Building Code Congress International, Inc. (See ICC)</td>
<td></td>
</tr>
<tr>
<td>SCTE</td>
<td>Society of Cable Telecommunications Engineers</td>
<td>(800) 542-5040, (610) 363-6888</td>
</tr>
</tbody>
</table>
REFERENCES

SDI  Steel Deck Institute  www.sdi.org  (847) 458-4647

SDI  Steel Door Institute  www.steeldoor.org  (440) 899-0010

SEFA  Scientific Equipment and Furniture Association  www.sefalabs.com  (877) 294-5424  (516) 294-5424

SEI/ASCE  Structural Engineering Institute/American Society of Civil Engineers  (See ASCE)

SIA  Security Industry Association  www.siaonline.org  (866) 817-8888  (703) 683-2075

SJI  Steel Joist Institute  www.steeljoist.org  (843) 293-1995

SMA  Screen Manufacturers Association  www.smainfo.org  (773) 636-0672

SMACNA  Sheet Metal and Air Conditioning Contractors' National Association  www.smaena.org  (703) 803-2980

SMPTE  Society of Motion Picture and Television Engineers  www.smpte.org  (914) 761-1100

SPFA  Spray Polyurethane Foam Alliance  www.sprayfoam.org  (800) 523-6154

SPIB  Southern Pine Inspection Bureau  www.spib.org  (850) 434-2611

SPRI  Single Ply Roofing Industry  www.spri.org  (781) 647-7026


SSINA  Specialty Steel Industry of North America  www.ssina.com  (800) 982-0355  (202) 342-8630

SSPC  SSPC: The Society for Protective Coatings  www.sspc.org  (877) 281-7772  (412) 281-2331

STI  Steel Tank Institute  www.steeltank.com  (847) 438-8265

SWI  Steel Window Institute  www.steelwindows.com  (216) 241-7333

SWPA  Submersible Wastewater Pump Association  www.swpa.org  (847) 681-1868
TCA  Tilt-Up Concrete Association  (319) 895-6911
    www.tilt-up.org

TCNA  Tile Council of North America, Inc.  (864) 646-8453
    (Formerly: Tile Council of America)
    www.tileusa.com

TEMATubular Exchanger Manufacturers Association, Inc.  (914) 332-0040
    www.tema.org

TIA  Telecommunications Industry Association  (703) 907-7700
    (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance)
    www.tiaonline.org

TIA/EIA  Telecommunications Industry Association/Electronic Industries Alliance  (See TIA)

TMS  The Masonry Society  (303) 939-9700
    www.masonrysociety.org

TPI  Truss Plate Institute  (703) 683-1010
    www.tpiinst.org

TPI  Turfgrass Producers International  (800) 405-8873
    www.turfgrasse.org  (847) 649-5555

TRITile Roofing Institute  (312) 670-4177
    www.tileroofing.org

UBC  Uniform Building Code  (See ICC)
    www.uniformbuilding.org

UL  Underwriters Laboratories Inc.  (877) 854-3577
    www.ul.com

UNI Uni-Bell PVC Pipe Association  (972) 243-3902
    www.uni-bell.org

USAV  USA Volleyball  (888) 786-5539
    www.usavolleyball.org  (719) 228-6800

USGBC  U.S. Green Building Council  (800) 795-1747
    www.usgbc.org

USITT  United States Institute for Theatre Technology, Inc.  (800) 938-7488
    www.usitt.org  (315) 463-6463

WASTEC  Waste Equipment Technology Association  (800) 424-2869
    www.wastec.org  (202) 244-4700

WCLIB  West Coast Lumber Inspection Bureau  (800) 283-1486
    www.wclib.org  (503) 639-0651

REFERENCES
WCMA  Window Covering Manufacturers Association  (212) 297-2122
                   www.wcmanet.org

WDMA  Window & Door Manufacturers Association  (800) 223-2301
                   www.wdma.com  (312) 321-6802

WI  Woodwork Institute  (Formerly:  WIC - Woodwork Institute of California)  (916) 372-9943
                   www.wicnet.org

WMMPA  Wood Moulding & Millwork Producers Association  (See MMPA)

WSRCA  Western States Roofing Contractors Association  (800) 725-0333
                   www.wsrca.com  (650) 938-5441

WWPA  Western Wood Products Association  (503) 224-3930
                   www.wwpa.org

B. Code Agencies:  Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list.  Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

DIN  Deutsches Institut für Normung e.V.  49 30 2601-0
                   www.din.de

IAPMO  International Association of Plumbing and Mechanical Officials  (909) 472-4100
                   www.iapmo.org

ICC  International Code Council  (888) 422-7233
                   www.iccsafe.org

ICC-ES  ICC Evaluation Service, LLC  (800) 423-6587
                   www.icc-es.org  (562) 699-0543

C. Federal Government Agencies:  Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list.  Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.

COE  Army Corps of Engineers  (202) 761-0011
                   www.usace.army.mil

CPSC  Consumer Product Safety Commission  (800) 638-2772
                   www.cpsc.gov  (301) 504-7923

DOC  Department of Commerce  (301) 975-4040
                   National Institute of Standards and Technology
                   www.nist.gov

DOD  Department of Defense  (215) 697-2664
                   http://dodssp.daps.dla.mil

DOE  Department of Energy  (202) 586-9220
                   www.energy.gov

REFERENCES  01 42 00 - 15
D. Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the standards and regulations in the following list. Names, telephone numbers, and Web sites are subject to change and are believed to be accurate and up-to-date as of the date of the Contract Documents.
<table>
<thead>
<tr>
<th>Code</th>
<th>Reference</th>
<th>Phone</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOD</td>
<td>Department of Defense</td>
<td>(215) 697-2664</td>
<td>Available from Department of Defense Single Stock Point <a href="http://dodssp.daps.dla.mil">http://dodssp.daps.dla.mil</a></td>
</tr>
<tr>
<td>DSCC</td>
<td>Defense Supply Center Columbus</td>
<td></td>
<td>(See FS)</td>
</tr>
<tr>
<td>FED-STD</td>
<td>Federal Standard</td>
<td></td>
<td>(See FS)</td>
</tr>
<tr>
<td></td>
<td>Available from Defense Standardization Program</td>
<td></td>
<td><a href="http://www.dsp.dla.mil">www.dsp.dla.mil</a></td>
</tr>
<tr>
<td></td>
<td>Available from General Services Administration</td>
<td>(800) 488-3111</td>
<td><a href="http://www.gsa.gov">www.gsa.gov</a></td>
</tr>
<tr>
<td>MILSPEC</td>
<td>Military Specification and Standards</td>
<td></td>
<td>(See DOD)</td>
</tr>
<tr>
<td>USAB</td>
<td>United States Access Board</td>
<td>(800) 872-2253</td>
<td><a href="http://www.access-board.gov">www.access-board.gov</a></td>
</tr>
<tr>
<td></td>
<td>(202) 272-0080</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USATBCB</td>
<td>U.S. Architectural &amp; Transportation Barriers Compliance Board</td>
<td>(See USAB)</td>
<td></td>
</tr>
</tbody>
</table>

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 42 00
SECTION 01 50 00
TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes requirements for temporary utilities, support facilities, and security and protection facilities.

1. Nothing in this Section is intended to limit types and amounts of temporary work required, and no omission from this Section will be recognized as an indication by Architect/Engineer that such temporary activity is not required for successful completion of the Work. The use of alternative facilities equivalent to those specified is the Contractor's option, subject to Architect/Engineer's and University acceptance.

B. Related Requirements:

1. Section 01 10 00 "Summary" for work restrictions and limitations on utility interruptions.
2. Section 01 35 46 “Indoor Air Quality” for temporary facility work including HVAC, air filtration, moisture management, air filtration and dust control partitions required to comply with indoor air quality requirements during construction.

1.3 USE CHARGES

A. General: Installation and removal of and use charges for temporary facilities shall be included in the Contract Sum unless otherwise indicated. Allow other entities to use temporary services and facilities without cost, including, but not limited to, University's construction forces, Architect/Engineer, testing agencies, and authorities having jurisdiction.

B. Use Charges: As follows:

1. For new construction: Arrange for and pay for water, sewer, electric power, steam and chilled water use charges for utility usage by all entities for construction operations.
2. For renovations of existing facilities: Arrange for and University will pay for all use charges.

C. Temporary Metering: For all utility connection; sub-meter at point of connection to existing systems.

1. Temporary utility meter must be approved by University Campus Energy Engineer.
2. Meters shall be operational prior to any use of utility for temporary heating.
1.4 INFORMATIONAL SUBMITTALS

A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.

B. Erosion- and Sedimentation-Control Plan: Show compliance with requirements of EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.

C. Fire-Safety Program: Show compliance with requirements of NFPA 241 and authorities having jurisdiction. Indicate Contractor personnel responsible for management of fire-prevention program.

D. Dust- and HVAC-Control Plan: Submit coordination drawing and narrative that indicates the dust- and HVAC-control measures proposed for use, proposed locations, and proposed time frame for their operation. Identify further options if proposed measures are later determined to be inadequate. Include the following:
   1. Locations of dust-control partitions at each phase of work.
   2. HVAC system isolation schematic drawing.
   3. Location of proposed air-filtration system discharge.
   5. Other dust-control measures.

1.5 QUALITY ASSURANCE

A. General: Comply with governing regulations and utility company regulations and recommendations for the construction of temporary facilities including, but not necessarily limited to, code compliances, permits, inspections, testing, health, safety, pollution and environmental compliances.


D. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

E. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

F. Accessible Temporary Egress: Where temporary accessible egress from existing buildings or portions thereof is provided, comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

1.6 PROJECT CONDITIONS

A. Temporary Use of Permanent Facilities: Engage Installer of each permanent service to assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before University's acceptance, regardless of previously assigned responsibilities.

B. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not overload facilities, or permit them to interfere with progress. Do not allow hazardous, dangerous or unsanitary conditions, or public nuisances to develop or persist on the site.
PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide both new or used materials and equipment for temporary facilities, which are in substantially undamaged and serviceable condition. Provide types and qualities which are recognized in the construction industry as suitable for the intended use in each application. Comply with Utility Company requirements as applicable.

2.2 TEMPORARY FACILITIES

A. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.

B. Common-Use Field Office: Insulated, weather-tight, of sufficient size to accommodate needs of University, Architect/Engineer, and construction personnel office activities and to accommodate Project meetings specified in other Division 01 Sections. Keep office clean and orderly.

In consultation with University PM, A/E to develop scope of Field Office required and revise requirements in subparagraph below to suit project.

1. At a minimum, furnish and equip offices as follows:
   a. Furniture required for Project-site documents including file cabinets, plan tables, plan racks, and bookcases.
   b. Conference room of sufficient size to accommodate meetings of \[10\] \(<\text{Insert number}>\) individuals. Provide electrical power service and 120-V ac duplex receptacles, with no fewer than one receptacle on each wall. Furnish room with conference table, chairs, and 4-foot-square tack and marker boards.
   c. Drinking water and private toilet.
   d. Coffee machine and supplies.
   e. Heating and cooling equipment necessary to maintain a uniform indoor temperature of 68 to 72 deg F.
   f. Lighting fixtures capable of maintaining average illumination of 20 fc at desk height.

C. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate materials and equipment for construction operations.

1. Store combustible materials apart from building.
2. Comply with Section 01 10 00 “Summary” for use of site for staging areas.

2.3 EQUIPMENT

A. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.

B. Digital Camera: Minimum 12 megapixel; available in field office for use.

C. Thermometer: Outdoor, re-settable type indicating daily maximum and minimum temperatures.

1. Locate in a shaded-from-the-sun, conveniently readable location that will give reasonably accurate readings of the actual air temperature and be reached easily for resetting.

D. Air-Filtration Units: Primary and secondary HEPA-filter-equipped portable units with four-stage filtration. Provide single switch for emergency shutoff. Configure to run continuously.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate, expand and modify facilities as required by progress of the Work.

B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

C. Use qualified workers for the installation of temporary facilities.

3.2 TEMPORARY UTILITY INSTALLATION

A. General: Install temporary service or connect to existing service.

1. Arrange with utility company, University, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services. Comply with requirements in Section 01 10 00 “Summary” for existing utility disruption procedures.

B. Sewers and Drainage: Provide temporary utilities to remove effluent lawfully.

1. Connect temporary sewers to municipal system as directed by authorities having jurisdiction.

C. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction. Where available, connect to University's existing water service facilities. Clean and maintain water service facilities in a condition acceptable to University. At Substantial Completion, restore these facilities to condition existing before initial use.

1. Obtain and pay for all required water taps.

D. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with requirements of authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.

1. Toilets: Use of University's existing toilet facilities is not permitted.
2. Provide temporary toilets within available site area in location approved by University which will best serve the needs of construction personnel.
3. Supply and maintain toilet tissue, paper towels, paper cups and similar disposable materials as appropriate for each sanitary facility, and provide appropriate waste paper containers for used materials.
4. At Contractor’s option, provide drinking water for construction personnel by either water-system-connected drinking fountains or by containerized tap dispensers with paper cups (or both).

E. Heating: Provide temporary heating required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high
humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.

1. HVAC Equipment: Unless University authorizes use of permanent HVAC system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.
   a. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
   b. Heating Units: Listed and labeled for type of fuel being consumed, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
   c. Permanent HVAC System: If University authorizes use of permanent HVAC system for temporary use during construction, provide filter with MERV of 8 at each return-air and exhaust grille in system and remove at end of construction. Clean and adjust HVAC system and put in new condition before Completion as required in Section 01 77 00 "Closeout Procedures".

F. Isolation of Work Areas in Occupied Facilities: Prevent dust, fumes, and odors from entering occupied areas.

1. Prior to commencing work, isolate the HVAC system in area where work is to be performed.
   a. Disconnect supply and return ductwork in work area from HVAC systems servicing occupied areas.
   b. Maintain negative air pressure within work area using HEPA-equipped air-filtration units, starting with commencement of temporary partition construction, and continuing until removal of temporary partitions is complete.

2. Maintain dust partitions during the work. Use vacuum collection attachments on dust-producing equipment. Isolate limited work within occupied areas using portable dust-containment devices.

3. Perform daily construction cleanup and final cleanup using approved, HEPA-filter-equipped vacuum equipment.

G. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient condition required and minimize energy consumption.

1. Provide dehumidification systems when required to reduce substrate moisture levels to level required to allow installation or application of finishes.

H. Electric Power Service: Provide weatherproof, grounded, electric power service and distribution system of sufficient size, capacity, and power characteristics required for construction operations. Include, as required, transformers, overload protected disconnects, automatic ground fault interrupters and main distribution switchgear. Maintain equipment in a condition acceptable to University.

1. Install electric power service overhead unless otherwise indicated.
2. Where available capacity exists in existing system, connect temporary service to University's existing power source, as directed by University.
3. Provide separate connection for power and for lighting.
4. Provide sufficient 220v outlets for special tools, welding equipment and similar devices requiring such service at locations where required.
5. Provide sufficient circuits and duplex 120v single phase outlets so located that any part of the work can be reached with a 75 foot extension cord to accommodate normal power tools and supplemental lighting.

I. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, inspections, and traffic conditions.

1. Provide temporary light to levels and as required by governing regulations but not less than minimum 5 foot-candle illumination in all areas accessible to workers during hours they are at the job; minimum 10 foot-candles for shop areas; 20 foot-candles or more where detailed or finishing work is being done, supplemented as may be required.

2. Install and operate temporary lighting that fulfills security and protection requirements without operating entire system.

3. Install lighting for Project identification sign.

4. Where permanent light fixtures have been used for temporary lighting, supply temporary lamps and replace with new lamps at time of Completion.

5. Provide lighting in stairways and exits at all times.

J. Telephone Service: Provide temporary telephone service in Contractor’s field office and distribute to each work station.

1. Pay for line installation, monthly charges, and expenses necessary to extend service from minimum point of presence (MPOP) as determined by University I/S.

2. Provide temporary telephone service in common-use facilities for use by all construction personnel.

3. Provide answering machine and a dedicated telephone line for a facsimile machine.

4. Provide superintendent with cellular telephone or portable two-way radio for use when away from field office.

Retain option in paragraph below if coordinated with and agreed upon by the University Project Manager.

K. Data Service: Provide temporary data service line in Contractor’s field office. [Coordinate installation with University Information Services (I/S) Department who will provide and maintain service until notified by Contractor to terminate and remove instruments and lines.]

3.3 SUPPORT FACILITIES INSTALLATION

A. General: Comply with the following:

1. Provide construction for temporary offices, shops, and sheds located within construction area or within 30 feet of building lines that is noncombustible according to ASTM E 136. Comply with NFPA 241.

2. Maintain support facilities until Architect/Engineer schedules Substantial Completion inspection. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to University.

B. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations. Locate temporary roads and paved areas within construction limits indicated on Drawings.

1. Surface temporary access road with road base material of not less than 4 inch thickness and compact.

2. Provide temporary signage and temporary pedestrian accessways or other special considerations necessary for continued University operations.
3. Provide stop sign(s) at all points of egress from construction site to meet standards established in the Manual of Uniform Traffic Code Devices (MUTCD).
4. Maintain University access to areas affected by temporary access roads during inclement weather.
5. Provide dust-control treatment that is nonpolluting and nontracking. Reapply treatment as required to minimize dust.
6. Restore to original condition to satisfaction of University when no longer required.

C. Temporary Walks: Construct and maintain temporary walks around the construction work and to offices, toilets and similar locations on the site.

D. Traffic Controls: Comply with requirements of authorities having jurisdiction.
   1. Protect existing site improvements to remain including curbs, pavement, and utilities.
   2. Maintain access for fire-fighting equipment and access to fire hydrants.

E. Parking: Comply with requirements in Section 01 10 00 “Summary.”

F. Dewatering Facilities and Drains: Comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.
   1. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties or endanger permanent Work or temporary facilities.
   2. Remove snow and ice as required to minimize accumulations.

G. Project Signs: Provide Project signs at locations indicated or directed. Unauthorized signs are not permitted.
   Consult with the University Project Manager for extent of appropriate signage.
   1. Identification Signs: Unless otherwise indicated, provide 4 foot by 8 foot Project identification sign.
      a. Architect/Engineer will provide sign layout, including colors and graphics as approved by University Resident Architect through University Project Manager.
   2. Temporary Signs: Provide other signs as indicated and as required to inform public and individuals seeking entrance to Project.
      a. Provide temporary, directional signs for construction personnel and visitors.
   3. Engage an experience sign painter to apply required colors and graphics in a neat and professional manner.
   4. Maintain and touchup signs so they are legible at all times.

H. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with progress cleaning requirements in Section 01 73 00 "Execution."
   1. Obtain necessary permits and approvals from City and County of Denver.
   2. Provide waste chutes as required in accordance with applicable laws and regulations.

I. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel. The selection of type, size and number of hoisting facilities is the solely the responsibility of the Contractor.
1. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.

J. Temporary Elevator Use: Use of elevators is not permitted without prior written approval of the Architect/Engineer and University Project Manager.

1. If so approved, only one designated elevator may be used subject to the requirements of “Existing Elevator Use” paragraph below.

K. Existing Elevator Use: When approved by University, one designated existing elevator may be used at no charge to Contractor or other subcontractors for transporting personnel, small tools, materials, and equipment. Comply with requirements of Section 01 10 00 “Summary” and the following:

1. Contractor will not be granted exclusive use of the designated elevator. University personnel and staff will be permitted to use this elevator as their work duties require.
2. Entire car is lined (floor, walls, ceiling) with 3/4 inch Fir plywood or equivalent.
3. Total load carried does not exceed rated capacity of elevator.
4. No materials, equipment, trash, tools or other items too large to be readily moved into and out of the car may be carried in the elevator.
5. Before acceptance of the building, linings are removed; all exposed surfaces are in new condition; all controls, relays, other parts showing any wear have been replaced.
6. Entire elevator, including machinery, electrical components, doors, operators and controls shall be tested, adjusted, and put in new condition with specified warranties and maintenance to take effect at date of Completion Certificate.
7. Written clearance has been obtained from the Elevator Service Company stating that the installation is safe and complete for this use prior to using it.
8. The Contractor signs the Elevator Service Company's standard agreement and release forms for this usage and pays charges for maintenance, service, repairs, and reconditioning.

L. Temporary Stairs: Until permanent stairs are available, provide temporary stairs where ladders are not adequate.

M. Existing Stair Usage: Use of University's existing stairs will be permitted, provided stairs are cleaned and maintained in a condition acceptable to University. At Substantial Completion, restore stairs to condition existing before initial use.

1. Provide protective coverings, barriers, devices, signs, or other procedures to protect stairs and to maintain means of egress. If stairs become damaged, restore damaged areas so no evidence remains of correction work.

N. Temporary Use of Permanent Stairs: Use of new stairs for construction traffic will be permitted, provided stairs are protected and finishes restored to new condition at time of Substantial Completion.

3.4 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.

B. Protection of Work: Protect in-progress and completed work from damage or deterioration, other than normal weathering of exposed materials, through construction duration until completion, as appropriate and as recommended by manufacturer and Installer.
1. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings. Protect finished floors and stairs from traffic, movement of heavy objects, and storage.
2. Prohibit traffic and storage on waterproofed and roofed surfaces, on lawn and landscaped areas.
3. Always protect excavation, trenches, and building, from damage from rain water, spring water, ground water, backing up of drains or sewers. Provide pumps, equipment, enclosures, to provide this protection.
4. Remove protective coverings and materials at the appropriate time but no later than final cleaning operations.

C. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

1. Comply with work restrictions specified in Section 01 10 00 "Summary."

D. Temporary Erosion and Sedimentation Control: Provide measures to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to undisturbed areas and to adjacent properties and walkways, according to requirements of 2003 EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.

1. Comply with Section 01 41 00 “Regulatory Requirements” Article “MS4 Storm Water and Water Quality Permits.”
2. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross tree- or plant- protection zones.
3. Inspect, repair, and maintain erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
4. Clean, repair, and restore adjoining properties and roads affected by erosion and sedimentation from Project site during the course of Project.
5. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

E. Stormwater Control: Comply with Section 01 41 00 “Regulatory Requirements” Article “MS4 Storm Water and Water Quality Permits.”

F. Tree and Plant Protection: Install temporary fencing or guard located outside the drip line of trees to protect vegetation from damage arising out of construction operations, including cutting, breaking or skinning of roots and skinning or bruising of bark. Protect tree root systems from damage, flooding, and erosion.

1. Do not stockpile construction materials or excavated materials inside dripline.
2. University will identify historically recorded trees and vegetation not to be disturbed.
3. Water trees and other vegetation to remain as required to maintain their health for the duration of the Project.
4. Repair or replace trees and vegetation damaged by construction operations in a manner acceptable to Architect/Engineer. Use a qualified tree surgeon to perform the work.

G. Pest Control: Engage pest-control service to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using environmentally safe materials.

H. Site Enclosure Fence: Within 10 business days of mobilization, furnish and install site enclosure fence in a manner that will prevent people and animals from easily entering site except by entrance gates and will protect adjacent sites from damage or contamination.
1. **Extent of Fence:** As required to enclose entire Project site or portion determined sufficient to accommodate construction operations.

2. **Portable Chain-Link Fencing:** Minimum 2-inch, 0.148-inch-thick, galvanized-steel, chain-link fabric fencing; minimum 6 feet high with galvanized-steel pipe posts; minimum 2-3/8-inch-OD line posts and 2-7/8-inch-OD corner and pull posts, with 1-5/8-inch-OD top and bottom rails. Provide bases for supporting posts.

3. **Locate so base supports do not extend outside work area where adjacent to walkways.**

4. **Maintain security by limiting number of keys and restricting distribution to authorized personnel.** Furnish one set of keys to University.

I. **Security:** Provide security program and facilities to protect the Work, existing facilities, and University operations and to prevent unauthorized entrance, vandalism, theft, and similar violations of security.

1. **Coordinate with University Police.**

2. **Provide lockable entrances and lock entrances at end of each work day.**

3. **After review and approval by University, install temporary enclosure around partially completed areas of construction.**

4. **Storage:** Where materials and equipment must be stored, and are of value or attractive for theft, provide a secure lockup. Enforce discipline in connection with the installation and release of material to minimize the opportunity for theft and vandalism.

J. **Barricades, Warning Signs, and Lights:** Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting wherever required to prevent accidents and losses.

K. **Temporary Egress:** Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.

L. **Covered Walkway:** Where regulations require or where a public roadway/walkway adjoins the Project site and materials may be hoisted across the walkway, erect protective, covered walkway for passage of individuals through or adjacent to Project site. Coordinate with entrance gates, other facilities, and obstructions. Comply with regulations of authorities having jurisdiction.

1. **Construct covered walkways using scaffold or shoring framing.**

2. **Provide overhead waterproof decking, protective enclosure walls, handrails, barricades, warning signs, exit signs, lights, safe and well-drained walkways, and similar provisions for protection and safe passage.**

3. **Paint and maintain appearance of walkway for duration of the Work in a manner acceptable to the Architect/Engineer and University.**

4. **Extend back wall beyond structure to complete the enclosure fence.**

M. **Temporary Enclosures:** Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weathertight enclosure for building exterior.

1. **Where heating or cooling is needed and permanent enclosure is incomplete, insulate temporary enclosures.**

2. **Coordinate temporary enclosures with ventilating and drying-of-the-work requirements, so as to avoid dangerous conditions and deleterious effects.**

3. **Close openings through floor or roof decks and horizontal surfaces with load-bearing wood-framed construction.**

N. **Temporary Partitions:** Provide floor-to-floor or floor-to-ceiling dustproof partitions terminating in dustproof floor or ceiling above to limit dust and dirt migration and to separate existing active elevator
hoistways and other areas occupied by University from dust, fumes and noise in compliance with Section 01 35 46 “Indoor Air Quality” and the following:

1. Construct dustproof partitions with 5/8 inch gypsum wallboard with joints taped on occupied side, and 1/2 inch fire-retardant-treated plywood on construction operations side.
2. Where fire-resistance-rated temporary partitions are indicated or are required by authorities having jurisdiction, construct partitions according to the rated assemblies.
3. Insulate partitions to control noise transmission to occupied areas.
4. Seal joints and perimeter. Equip partitions with gasketed dustproof doors and security locks where openings are required.
5. Protect air-handling equipment.
6. Provide walk-off mats at each entrance through temporary partition.
7. At elevator hoistway entrances not used during construction, seal openings with plastic sheet and duct tape.

O. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241; manage fire-prevention program.

1. Fire Extinguishers: Minimum one per floor at or near useable exit.
   a. Provide additional extinguishers where convenient and effective for intended purpose.
   b. Comply with NFPA 10 to the extent applicable.
2. Strictly enforce site prohibition against smoking.
3. Supervise welding operations, combustion-type temporary heating units, and similar sources of fire ignition according to requirements of authorities having jurisdiction.
4. Develop and supervise an overall fire-prevention and protection program for personnel at Project site. Coordinate with University Project Manager to review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.
5. Provide temporary standpipes and hoses for fire protection. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.
6. Maintain unobstructed access to fire extinguishers, temporary fire protection facilities, stairways and other access routes for fighting fires.
7. Store combustible materials in containers in fire-safe locations.
8. Permanent Fire Protection System: Complete and make operational at earliest possible date. Instruct site personnel on use of permanent system.

3.5 MOISTURE AND MOLD CONTROL

A. Contractor's Moisture-Protection Plan: Comply with requirements in Section 01 35 46 “Indoor Air Quality Procedures.”

3.6 OPERATION, TERMINATION, AND REMOVAL

A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.

1. Do not permit temporary offices and similar temporary or permanent spaces to be used as living quarters or for other unintended occupancies or uses.
B. Maintenance: Maintain facilities in good operating condition until removal.
   1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and
      similar facilities on a 24-hour basis where required to achieve indicated results and to avoid
      possibility of damage.

C. Janitorial Services: Provide daily janitorial services for temporary offices, toilets, and similar areas at the
   project site. Require users of other temporary facilities to maintain clean and orderly premises.

D. Operate Project-identification-sign lighting daily from dusk until 12:00 midnight.

E. Temporary Facility Changeover: Do not change over from using temporary security and protection
   facilities to permanent facilities until Substantial Completion.

F. Termination and Removal: Remove each temporary facility when need for its service has ended, when it
   has been replaced by authorized use of a permanent facility, or no later than Substantial Completion,
   unless Architect/Engineer requests that it be retained for a longer period of time. Complete or, if
   necessary, restore permanent construction that may have been delayed because of interference with
   temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot
   be satisfactorily repaired.
   1. Materials and facilities that constitute temporary facilities are property of Contractor. University
      reserves right to take possession of Project identification signs.
   2. At Substantial Completion, repair, renovate, and clean permanent facilities used during
      construction period. Comply with final cleaning requirements specified in Section 01 77 00
      "Closeout Procedures."

END OF SECTION 01 50 00
SECTION 01 60 00
PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.

B. Related Requirements:
   1. Section 01 21 00 "Allowances" for products selected under an allowance, if applicable.
   2. Section 01 23 00 "Alternates" for products selected under an alternate, if applicable.
   3. Section 01 25 00 "Substitution Procedures" for requests for substitutions.
   4. Section 01 42 00 "References" for applicable industry standards for products specified.
   5. Section 01 77 00 “Closeout Procedures” for submittal of project warranties.

1.3 DEFINITIONS

A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.

   1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature, that is current as of date of the Contract Documents.
   2. New Products: Items that have not previously been incorporated into another project or facility. Products salvaged or recycled from other projects are not considered new products.
   3. Comparable Product: Product that is demonstrated and approved through submittal process to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

B. Basis-of-Design Product Specification: A specification in which a specific manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of additional manufacturers named in the specification.
1.4 ACTION SUBMITTALS

A. Comparable Product Requests: Submit request for consideration of each comparable product. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.

1. Requests for consideration of comparable products will only be entertained during bidding.
2. Include data to indicate compliance with the requirements specified in "Comparable Products" Article.
3. Architect/Engineer's Action: If necessary, Architect/Engineer will request additional information or documentation for evaluation of a comparable product request. Architect/Engineer will notify Contractor of approval or rejection of proposed comparable product.
   
   a. Form of Approval: Written Addendum.

B. Basis-of-Design Product Specification Submittal: Comply with requirements in Section 01 33 00 "Submittal Procedures." Show compliance with requirements.

1.5 QUALITY ASSURANCE

A. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options. The complete compatibility between the various choices available to the Contractor is not assured by the various requirements of the Contract Documents, but must be provided by the Contractor.

B. Source Limitations: To the fullest extent possible, provide products of the same kind, from a single source.

C. Nameplates: Except for required labels and operating data, do not attach or imprint manufacturers or producer's nameplates or trademarks on exposed surfaces of products which will be exposed to view in occupied spaces or on the exterior.

D. Labels: Locate required product labels and stamps on a concealed surface or, where required for observation after installation, on an accessible surface that is not conspicuous.

E. Equipment Nameplates: Provide a permanent nameplate on each item of service-connected or power-operated equipment. Locate on an easily accessible surface which is inconspicuous in occupied spaces. The nameplate shall contain the following information and other essential operating data.

   1. Name of product and manufacturer.
   2. Model and serial number.
   3. Capacity.
   4. Speed.
   5. Ratings.
   6. Power characteristics (if applicable).
   7. UL label or compliance (if applicable).

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.
**B. Delivery and Handling:**

1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.
2. Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to Project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

**C. Storage:**

1. Store products to allow for inspection and measurement of quantity or counting of units.
2. Store materials in a manner that will not endanger Project structure.
3. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
4. Protect foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
5. Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.
6. Protect stored products from damage and liquids from freezing.

**1.7 PRODUCT WARRANTIES**

**A.** Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents. Such disclaimers and limitations do not relieve warranty requirements on Work that incorporates product nor do they relieve suppliers, manufacturers and subcontractors required to countersign special warranties with the Contractor.

1. Manufacturer's Warranty: Written warranty furnished by individual manufacturer for a particular product and specifically endorsed by manufacturer to University.
2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for University.

**B. Special Warranties:** Prepare a written document that contains appropriate terms and identification, ready for execution.

1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed.
2. Specified Form: When specified forms are included with the Specifications, prepare a written document using indicated form properly executed.
3. See other Sections for specific content requirements and particular requirements for submitting special warranties.

**C. Submittal Time and Form:** Comply with requirements in Section 01 77 00 "Closeout Procedures."

**D. Warranty Requirements:**
1. Related Damages and Losses: When correcting warranted Work that has failed, remove and replace other Work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work.

2. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

3. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether the University has benefited from use of the Work through a portion of its anticipated useful service life.

4. University's Recourse:
   a. Written warranties made to the University are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the University can enforce such other duties, obligations, rights, or remedies.
   b. Rejection of Warranties: The University reserves the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the Contract Documents.
   c. The University reserves the right to refuse to accept Work for the Project where a special warranty, certification, or similar commitment is required on such Work or part of the Work, until evidence is presented that entities required to countersign such commitments are willing to do so.

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

A. General Product Requirements: Provide products that comply with the Contract Documents, are undamaged, are asbestos free, and, unless otherwise indicated, are new at time of installation.

1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.
2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.
3. University reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.
4. Where products are accompanied by the term "as selected," Architect/Engineer will make selection.
6. Or Equal: For products specified by name and accompanied by the term "or equal," or "or approved equal," or "or approved," comply with requirements in "Comparable Products" Article to obtain approval for use of an unnamed product and provide only products previously approved during bid phase by written Addendum. The determination of equivalence is at the sole discretion of the Architect/Engineer who has no obligation to prove non-equivalence.
7. Mechanical and electrical equipment design and their space requirements are based on the first named item of the Section in which specified or that scheduled on the Drawings. If other than the first named or scheduled item listed for use is selected, modification to other elements of Work may be required. Show all such modification on shop drawings and submittals as appropriate. The cost of such modifications is solely the responsibility of the Contractor.
8. Where manufacturers are listed as acceptable for specific proprietary products but precise identification by model, series, or trade name is not specified, submit detailed product information for such products for Architect/Engineer's acceptance prior to ordering. Include specific requirements for modifications to other construction, including but not limited to, power and utility requirements, characteristics, capacities, size and locations. The cost of such modifications is solely the responsibility of the Contractor.

B. Product Selection Procedures:

1. Product: Where Specifications name a single manufacturer and product, provide the named product that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

2. Manufacturer/Source: Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

3. Products:

   a. Restricted List: Where Specifications include a list of names of both manufacturers and products, provide one of the products listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

4. Manufacturers:

   a. Restricted List: Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

5. Basis-of-Design Product: Where Specifications name a product, or refer to a product indicated on Drawings, and include a list of manufacturers, provide the specified or indicated product or a comparable product by one of the other named manufacturers. If proposing a comparable product by another manufacturer, whether named or not, provide a custom product if manufacturer's standard product does not include salient features of the Basis-of-Design product indicated. Drawings and Specifications indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with requirements in "Comparable Products" Article for consideration of an unnamed product by one of the other named manufacturers.

6. Contractor's Option: Where materials, products, systems or methods are specified to be selected from a list of options, subject to compliance with requirements, the choice of which material, method, product or system will be solely at the Contractor's discretion. There will be no change in Contract Sum or Time because of such choice.

C. Visual Matching Specification: Where Specifications require "match Architect/Engineer's sample", provide a product that complies with requirements and matches Architect/Engineer's sample. Architect/Engineer's decision will be final on whether a proposed product matches.

1. If no product available within specified category matches and complies with other specified requirements, comply with requirements in Section 01 25 00 "Substitution Procedures" for proposal of product.

D. Visual Selection Specification: Where Specifications include the phrase "as selected by Architect/Engineer from manufacturer's full range" or similar phrase, select a product that complies with requirements. Architect/Engineer will select color, gloss, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.
2.2 COMPARABLE PRODUCTS

A. Conditions for Consideration: Prior to bid, Architect/Engineer will consider Contractor's request for comparable product when the following conditions are satisfied. If the following conditions are not satisfied, Architect/Engineer will reject request:

1. Evidence that the proposed product does not require revisions to the Contract Documents, that it is consistent with the Contract Documents and will produce the indicated results, and that it is compatible with other portions of the Work.
2. Detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
3. Evidence that proposed product provides specified warranty.
4. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners, if requested.
5. Samples, if requested.

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 60 00
SECTION 01 73 00

EXECUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:

2. Field engineering and surveying.
3. Installation of the Work.
4. Cutting and patching.
5. Coordination of University-installed products.
6. Progress cleaning.
7. Starting and adjusting.
8. Protection of installed construction.

B. Related Requirements:

1. Section 01 10 00 "Summary" for limits on use of Project site and procedures related to utility interruptions.

1.3 DEFINITIONS

A. Cutting: Removal of in-place construction necessary to permit installation or performance of other work.

B. Patching: Fitting and repair work required to restore construction to original conditions after installation of other work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For land surveyor or professional engineer.

B. Certificates: Submit certificate signed by land surveyor or professional engineer certifying that location and elevation of improvements comply with requirements.

C. Cutting and Patching Plan and Request: Submit plan and request describing procedures at least 21 calendar days prior to the time cutting and patching will be performed.

1. Submit request whenever cutting and patching operation affect:
EXECUTION

1. Include the following information:

a. Extent: Describe reason for and extent of each occurrence of cutting and patching, including explanation of why cutting and patching operation cannot be reasonable avoided.
b. Changes to In-Place Construction: Describe cutting and patching methods and anticipated results. Include changes to structural elements and operating components as well as changes in building appearance and other significant visual elements.
c. Products: List products to be used for patching and firms or entities that will perform patching work.
d. Trades: Indicate trades and subcontractors who will perform the work.
e. Dates: Indicate when cutting and patching will be performed.
f. Utilities and Mechanical and Electrical Systems: List services and systems that cutting and patching procedures will disturb or affect. List services and systems that will be relocated and those that will be temporarily out of service. Indicate length of time permanent services and systems will be disrupted.

1) Include description of provisions for temporary services and systems during interruption of permanent services and systems.
2) Comply with requirements of Section 01 10 00 “Summary” related to existing utility and system interruptions.

g. Structural Elements: Where cutting and patching structural elements requires the addition of reinforcement, submit details and calculations signed and sealed by an Engineer registered in the State of Colorado. Indicate how new reinforcing will be integrated with original structure.

3. Limitations: Approval of cutting and patching request does not waive right of Architect/Engineer or University to later require complete removal and replacement of work found to be unsatisfactorily cut and patched.

D. Certified Surveys: Submit two copies signed by land surveyor or professional engineer.

E. Final Property Survey: Submit one electronic and two paper copies showing the Work performed and record survey data.

1. Include certified statement that lines and levels of the work comply with the requirements of the Contract Documents and listing authorized or accepted deviations, cross-referenced to Change Order number, where applicable.

1.5 QUALITY ASSURANCE

A. Land Surveyor Qualifications: A professional land surveyor who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing land-surveying services of the kind indicated.
B. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.

1. Structural Elements: When cutting and patching structural elements, notify Architect/Engineer of locations and details of cutting and await directions from Architect/Engineer before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

2. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety. Operational elements include but are not limited to the following:
   a. Primary operational systems and equipment.
   b. Fire separation assemblies.
   c. Air or smoke barriers.
   d. Fire-suppression systems.
   e. Mechanical systems piping and ducts.
   f. Control systems.
   g. Communication systems.
   h. Fire-detection and alarm systems.
   i. Conveying systems.
   j. Electrical wiring systems.
   k. Operating systems of special construction.

3. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety. Other construction elements include but are not limited to the following:
   a. Water, moisture, or vapor barriers.
   b. Membranes and flashings.
   c. Exterior curtain-wall construction.
   d. Sprayed fire-resistive material.
   e. Equipment supports.
   f. Piping, ductwork, vessels, and equipment.
   g. Noise- and vibration-control elements and systems.

4. Visual Elements: Do not cut and patch construction exposed to the exterior or exposed in occupied spaces in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Architect/Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

5. Hazardous Materials: Do not proceed with cutting and patching operations until University has examined existing construction for the presence of asbestos and/or lead-based coatings. Comply with requirements in Section 01 35 00 “Special Procedures.”

C. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of products and equipment.
PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Comply with requirements specified in other Sections.

1. For projects requiring compliance with sustainable design and construction practices and procedures, use products for patching that comply with requirements in Division 01 Section “Sustainable Design Requirements.”

B. In-Place Materials: Use materials for patching identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

1. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Architect/Engineer for the visual and functional performance of in-place materials.

C. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

1. Use cleaning products that comply with Green Seal's GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work. Notify University Project Manager and Architect/Engineer and obtain approval prior to disturbing, moving or penetrating soil.

1. Arrange for locating buried utilities including water and sewer lines within construction limits. Obtain location information and stake all known utilities prior to commencing construction activities.

   a. Contact Utility Notification Center of Colorado (UNCC), 1-800-922-1987, and comply with UNCC guidelines.

2. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; underground electrical services, and other utilities.

3. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

B. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present, for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
4. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Existing Utility Information: Furnish information to local utility or University, as appropriate, that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Architect/Engineer according to requirements in Section 01 31 00 "Project Management and Coordination."

3.3 CONSTRUCTION LAYOUT

A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify Architect/Engineer promptly.

B. General: Engage a land surveyor or professional engineer to lay out the Work using accepted surveying practices.

1. Establish benchmarks and control points to set lines and levels at each story of construction and elsewhere as needed to locate each element of Project.
2. Establish limits on use of Project site.
3. Establish dimensions within tolerances indicated. Do not scale Drawings to obtain required dimensions.
4. Inform installers of lines and levels to which they must comply.
5. Check the location, level and plumb, of every major element as the Work progresses.
6. Notify Architect/Engineer when deviations from required lines and levels exceed allowable tolerances. Record deviation which are accepted (i.e., not corrected) on record drawings in accordance with the requirements of Section 01 78 39 “Project Record Documents.”
7. Close site surveys with an error of closure equal to or less than the standard established by authorities having jurisdiction.

C. Site Improvements: Locate and lay out site improvements, including pavements, grading, fill and topsoil placement, utility slopes, and rim and invert elevations.
D. Building Lines and Levels: Locate and lay out control lines and levels for structures, building foundations, column grids, and floor levels, including those required for mechanical and electrical work. Transfer survey markings and elevations for use with control lines and levels. Level foundations and piers from two or more locations.

E. Record Log: Maintain a log of layout control work. Record deviations from required lines and levels. Include beginning and ending dates and times of surveys, weather conditions, name and duty of each survey party member, and types of instruments and tapes used. Make the log available for reference by Architect/Engineer.

### 3.4 FIELD ENGINEERING

A. Identification: University will identify existing benchmarks, control points, and property corners.

B. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.

   1. Do not change or relocate existing benchmarks or control points without prior written approval of Architect/Engineer. Report lost or destroyed permanent benchmarks or control points promptly. Report the need to relocate permanent benchmarks or control points to Architect/Engineer before proceeding.
   2. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.

C. Benchmarks: Establish and maintain a minimum of two permanent benchmarks on Project site, referenced to data established by survey control points. Comply with authorities having jurisdiction for type and size of benchmark.

   1. Record benchmark locations, with horizontal and vertical data, on Project Record Documents.
   2. Where the actual location or elevation of layout points cannot be marked, provide temporary reference points sufficient to locate the Work.
   3. Remove temporary reference points when no longer needed. Restore marked construction to its original condition.

D. Certified Survey: On completion of foundation walls, major site improvements, and other work requiring field-engineering services, prepare a certified survey showing dimensions, locations, angles, and elevations of construction and sitework.

E. Final Property Survey: Engage a land surveyor or professional engineer to prepare a final property survey showing significant features (real property) for Project. Include on the survey a certification, signed by land surveyor or professional engineer, that principal metes, bounds, lines, and levels of Project are accurately positioned as shown on the survey.

   1. Show boundary lines, monuments, streets, site improvements and utilities, existing improvements and significant vegetation, adjoining properties, acreage, grade contours, and the distance and bearing from a site corner to a legal point.
   2. Recording: At Substantial Completion, have the final property survey recorded by or with authorities having jurisdiction as the official "property survey."
3.5 INSTALLATION

A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
   1. Make vertical work plumb and make horizontal work level.
   2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
   3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated to the extent they are more explicit or stringent than requirements of the Contract Documents.

C. Install products at the time and under conditions, including weather that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

D. Isolate each part of complete installation from incompatible material as needed to prevent deterioration.

E. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

F. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.

G. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.

H. Templates: Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.

I. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned, true and level as applicable, with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions.
   1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect/Engineer.
   2. Allow for building movement, including thermal expansion and contraction.
   3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

J. Attachment to Concrete:
   1. No drilled inserts or powder-actuated fasteners are permitted in pre-stressed concrete except as specifically authorized by Contractor and carried out under the direct supervision of its Superintendent.
   2. Only those devices with a maximum controlled penetration of 3/4 inch or less will be permitted. Make holes through slabs by means of sleeves placed no closer than 2 inch from tensioning cables. Core drilling will not be permitted unless unavoidable and as specified for cutting and patching in this Section.
K. Joints: Unless indicated otherwise, make joints of uniform width. Where joint locations in exposed work are required but not indicated, arrange joints for the best visual effect. Confirm arrangement with Architect/Engineer before proceeding. Fit exposed connections together to form hairline joints.

L. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.6 CUTTING AND PATCHING

A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

B. Responsibility: Provide cutting and patching work, including attendant excavation and backfill required to complete the Work or to:

1. Make components fit together properly.
2. Uncover portions of the Work to provide for installation of ill-timed work.
3. Remove and replace defective work or work not conforming to requirements of Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Provide routine penetrations of non-structural surfaces for installation of piping and electrical conduit.

C. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during installation or cutting and patching operations, by methods and with materials so as not to void existing warranties.

D. Temporary Support: Provide temporary support of work to be cut.

E. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

F. Adjacent Occupied Areas: Where interference with use of adjoining areas or interruption of free passage to adjoining areas is unavoidable, coordinate cutting and patching according to requirements in Section 01 10 00 "Summary."

G. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to minimize interruption to occupied areas, coordinate cutting and patching according to requirements in Section 01 10 00 "Summary."

H. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations. Employ methods which will prevent settlement or damage to other work.
5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
6. Proceed with patching after construction operations requiring cutting are complete.

I. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements, including tolerance, specified in other Sections, where applicable.

1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate physical integrity of installation.
2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
   a. Clean piping, conduit, and similar features before applying paint or other finishing materials.
   b. Restore damaged pipe covering to its original condition.

3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
   a. Where patching occurs in a painted surface, prepare substrate and apply primer and intermediate paint coats appropriate for substrate over the patch, and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.
4. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition and ensures thermal and moisture integrity of building enclosure.

J. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.7 UNIVERSITY-INSTALLED PRODUCTS

A. Site Access: Provide access to Project site for University's construction personnel.
B. Coordination: Coordinate construction and operations of the Work with work performed by University's construction personnel.

1. Construction Schedule: Inform University of Contractor's preferred construction schedule for University's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify University if changes to schedule are required due to differences in actual construction progress.
2. Preinstallation Conferences: Include University's construction personnel at preinstallation conferences covering portions of the Work that are to receive University's work. Attend preinstallation conferences conducted by University's construction personnel if portions of the Work depend on University's construction.

3.8 PROGRESS CLEANING

A. General: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

2. Do not hold waste materials more than seven calendar days during normal weather or three calendar days if the temperature is expected to rise above 80 deg F.
3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.
   a. Use containers intended for holding waste materials of type to be stored.

B. Collection Point: Review location with University and obtain approval.

C. Site: Maintain Project site free of waste materials and debris.

D. Wind Blown Debris: Prevent spread of trash, debris, cartons, packing material, or other waste on or off Project site by wind.

E. Dust: Sprinkle dusty debris with water.

F. Packing Materials: Immediately after uncrating or unpacking materials or equipment, remove all crating, lumber, excelsior, wrapping or other like combustible materials from building to central collection facility.

G. Work Areas: Clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
   1. Remove liquid spills promptly.
   2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.

H. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.

I. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

J. Exposed Surfaces in Finished Areas: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

K. Waste Disposal: Do not bury or burn waste materials on-site. Do not wash waste materials down sewers or into waterways. Comply with waste disposal requirements in Section 01 74 19 "Construction Waste Management and Disposal."
L. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

M. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

N. Limiting Exposures: Supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

O. Snow and Ice: Remove snow and ice from sidewalks adjacent to site and from access ways to building and construction site.

P. Streets: At frequency required by University and/or governing authority, clean adjacent and nearby streets of dirt resulting from construction operations.

3.9 STARTING AND ADJUSTING

A. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.

B. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.

C. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Manufacturer's Field Service: Comply with qualification requirements in Section 01 40 00 "Quality Requirements."

3.10 PROTECTION OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Comply with manufacturer's written instructions for temperature and relative humidity.

C. Limiting Exposures: Supervise construction activities to ensure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period. Where applicable, such exposures include, but are not limited to, the following:

1. Excessive static or dynamic loading.
2. Excessive internal or external pressures.
3. Excessively high or low temperatures.
4. Thermal shock.
5. Excessively high or low humidity.
6. Air contamination or pollution.
7. Water or ice.
8. Solvents.
10. Light.
11. Radiation.
12. Puncture.
13. Abrasion.
14. Heavy traffic.
15. Soiling, staining and corrosion.
16. Bacteria.
17. Rodent and insect infestation.
19. Electrical current.
20. High speed operation.
21. Improper lubrication.
22. Unusual wear or other misuse.
23. Contact between incompatible materials.
24. Misalignment.
25. Excessive weathering.
27. Improper shipping or handling.
28. Theft.
29. Vandalism.

END OF SECTION 01 73 00
SECTION 01 74 19
CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

INCLUDE THIS SECTION IN PROJECT SPECIFICATION ONLY FOR PROJECTS REQUIRED TO OBTAIN LEED CERTIFICATION.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Salvaging nonhazardous [demolition] [and] construction waste.
2. Recycling nonhazardous [demolition] [and] construction waste.
3. Disposing of nonhazardous [demolition] [and] construction waste.

B. Related Requirements:

1. Section 02 41 16 "Structure Demolition" for disposition of waste resulting from demolition of buildings, structures, and site improvements.
2. Section 02 41 19 "Selective Demolition" for disposition of waste resulting from partial demolition of buildings, structures, and site improvements.
3. Section 04 20 00 "Unit Masonry" for disposal requirements for masonry waste.
5. Section 04 43 13.16 "Adhered Stone Masonry Veneer" for disposal requirements for excess stone and stone waste.
6. Section 31 10 00 "Site Clearing" for disposition of waste resulting from site clearing and removal of above- and below-grade improvements.

1.3 DEFINITIONS

A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.

B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.
C. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.

D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.

E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.

F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

1.4 PERFORMANCE REQUIREMENTS

A. General: Achieve end-of-Project rates for salvage/recycling of minimum 75 percent by weight of total non-hazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials, including the following:

1. Demolition Waste:
   a. Asphalt paving.
   b. Concrete.
   c. Concrete reinforcing steel.
   d. Brick.
   e. Concrete masonry units.
   f. Wood studs.
   g. Wood joists.
   h. Plywood and oriented strand board.
   i. Wood paneling.
   j. Wood trim.
   k. Structural and miscellaneous steel.
   l. Rough hardware.
   m. Roofing.
   n. Insulation.
   o. Doors and frames.
   p. Door hardware.
   q. Windows.
   r. Glazing.
   s. Metal studs.
   t. Gypsum board.
   u. Acoustical tile and panels.
   v. Carpet.
   w. Carpet pad.
   x. Demountable partitions.
   y. Equipment.
   z. Cabinets.
   aa. Plumbing fixtures.
   bb. Piping.
   cc. Supports and hangers.
   dd. Valves.
   ee. Sprinklers.
   ff. Mechanical equipment.
   gg. Refrigerants.
   hh. Electrical conduit.
ii. Copper wiring.
jj. Lighting fixtures.
kk. Lamps.
ll. Ballasts.
mm. Electrical devices.
nn. Switchgear and panelboards.
oo. Transformers.

2. Construction Waste:
   a. Masonry and CMU.
   b. Lumber.
   c. Wood sheet materials.
   d. Wood trim.
   e. Metals.
   f. Roofing.
   g. Insulation.
   h. Carpet and pad.
   i. Gypsum board.
   j. Piping.
   k. Electrical conduit.
   l. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following uncontaminated packaging materials:
      1) Paper.
      2) Cardboard.
      3) Boxes.
      4) Plastic sheet and film.
      5) Polystyrene packaging.
      7) Plastic pails.

1.5 ACTION SUBMITTALS

A. Waste Management Plan: Submit plan within 30 calendar days of date established for the Notice to Proceed.

1.6 INFORMATIONAL SUBMITTALS

A. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit report. Use Form CWM-7 for construction waste and Form CWM-8 for demolition waste, as applicable. Include the following information:

1. Material category.
2. Generation point of waste.
3. Total quantity of waste in tons.
4. Quantity of waste salvaged, both estimated and actual in tons.
5. Quantity of waste recycled, both estimated and actual in tons.
6. Total quantity of waste recovered (salvaged plus recycled) in tons.
7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.

B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
C. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.

D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.

E. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

F. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

G. LEED Submittal: LEED letter template for "Construction and Demolition Debris Management Planning" credit, signed by Contractor, tabulating total waste material, quantities diverted and means by which it is diverted, and statement that requirements for the credit have been met.

Retain “Qualification Data” and “Statement of Refrigerant Recovery” Paragraphs below only if applicable to Project.

H. Qualification Data: For refrigerant recovery technician.

I. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

1.7 QUALITY ASSURANCE

Retain “Refrigerant Recovery Technician Qualification” Paragraph below only if applicable to Project.

A. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.

B. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Waste Management Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Review methods and procedures related to waste management including, but not limited to, the following:

1. Review and discuss waste management plan including responsibilities of waste management coordinator.
2. Review requirements for documenting quantities of each type of waste and its disposition.
3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
5. Review waste management requirements for each trade.

1.8 WASTE MANAGEMENT PLAN

A. General: Develop a waste management plan according to ASTM E 1609 and requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue
CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

analysis. Where Project includes demolition, distinguish between demolition and construction waste. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.

B. Waste Identification: Indicate anticipated types and quantities of demolition, site-clearing, and construction waste, as applicable, generated by the Work. Use Form CWM-1 for construction waste and Form CWM-2 for demolition waste. Include estimated quantities and assumptions for estimates.

C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Use Form CWM-3 for construction waste and Form CWM-4 for demolition waste. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.

1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.
3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.

1. Comply with operation, termination, and removal requirements in Section 01 50 00 "Temporary Facilities and Controls."

B. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan. Based on Project size and complexity, waste management coordinator may, if approved in writing by Architect/Engineer and University Project Manager, serve in other construction related roles.

C. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.

1. Distribute waste management plan to everyone concerned within three business days of submittal return.
2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
D. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.
2. Comply with Section 01 50 00 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

Retain entire Article below only for Projects that include demolition.

3.2 SALVAGING DEMOLITION WASTE

A. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until installation.
4. Protect items from damage during transport and storage.
5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.

B. Salvaged Items for Sale and Donation: Not permitted on Project site.

C. Salvaged Items for University's Use: Salvage items for University's use and handle as follows:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until delivery to University.
4. Transport items to University's storage area designated by University.
5. Protect items from damage during transport and storage.

D. Doors and Hardware: Brace open end of door frames. Except for removing door closers, leave door hardware attached to doors.

E. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.

F. Plumbing Fixtures: Separate by type and size.

G. Lighting Fixtures: Separate lamps by type and protect from breakage.

H. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

Retain options in Article Title below only for Projects that include demolition.

3.3 RECYCLING [DEMOLITION] [AND] CONSTRUCTION WASTE, GENERAL

A. General: Recycle paper and beverage containers used by on-site workers.
B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to Contractor.

C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.

D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.

1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
   a. Inspect containers and bins for contamination and remove contaminated materials if found.

2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
4. Store components off the ground and protect from the weather.
5. Remove recyclable waste from University's property and transport to recycling receiver or processor.

3.4 RECYCLING DEMOLITION WASTE

A. Asphalt Paving: Grind asphalt to maximum 1-1/2-inch size.
1. Crush asphaltic concrete paving and screen to comply with requirements in Section 31 20 00 "Earth Moving" for use as general fill.

B. Asphalt Paving: Break up and transport paving to asphalt-recycling facility.

C. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.
1. Pulverize concrete to maximum 1-1/2-inch size.
2. Crush concrete and screen to comply with requirements in Section 31 20 00 "Earth Moving" for use as satisfactory soil for fill or subbase.

D. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.
1. Pulverize masonry to maximum 3/4-inch size.
   a. Crush masonry and screen to comply with requirements in Section 31 20 00 "Earth Moving" for use as satisfactory soil for fill or subbase.
   b. Crush masonry and screen to comply with requirements in Section 32 93 00 "Plants" for use as mineral mulch.
2. Clean and stack undamaged, whole masonry units on wood pallets.

E. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.

F. Metals: Separate metals by type.
1. Structural Steel: Stack members according to size, type of member, and length.
2. Remove and dispose of bolts, nuts, washers, and other rough hardware.

G. Asphalt Shingle Roofing: Separate organic and glass-fiber asphalt shingles and felts. Remove and dispose of nails, staples, and accessories.

H. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.

I. Acoustical Ceiling Panels and Tile: Stack large clean pieces on wood pallets and store in a dry location.

J. Metal Suspension System: Separate metal members including trim, and other metals from acoustical panels and tile and sort with other metals.

K. Carpet and Pad: Roll large pieces tightly after removing debris, trash, adhesive, and tack strips.
   1. Store clean, dry carpet and pad in a closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.

L. Carpet Tile: Remove debris, trash, and adhesive.
   1. Stack tile on pallet and store clean, dry carpet in a closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.

M. Piping: Reduce piping to straight lengths and store by type and size. Separate supports, hangers, valves, sprinklers, and other components by type and size.

N. Conduit: Reduce conduit to straight lengths and store by type and size.

3.5 RECYCLING CONSTRUCTION WASTE

A. Packaging:
   1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
   3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
   4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.

B. Wood Materials:
   1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
   2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.

C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location.
   1. Clean Gypsum Board: If gypsum board is processed on site, grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding. At Contractor’s option, processing may occur off site.
3.6 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.

1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. Burning: Do not burn waste materials.

C. Disposal: Remove waste materials from University's property and legally dispose of them.

3.7 ATTACHMENTS

A. Form CWM-1 for construction waste identification.

B. Form CWM-2 for demolition waste identification.

C. Form CWM-3 for construction waste reduction work plan.

D. Form CWM-4 for demolition waste reduction work plan.

E. Form CWM-7 for construction waste reduction progress report.

F. Form CWM-8 for demolition waste reduction progress report.

END OF SECTION 01 74 19
## FORM CWM-1: CONSTRUCTION WASTE IDENTIFICATION

<table>
<thead>
<tr>
<th>MATERIAL CATEGORY</th>
<th>GENERATION POINT</th>
<th>EST. QUANTITY OF MATERIALS RECEIVED* (A)</th>
<th>EST. WASTE - % (B)</th>
<th>TOTAL EST. QUANTITY OF WASTE* (C = A x B)</th>
<th>EST. VOLUME CY (CM)</th>
<th>EST. WEIGHT TONS (TONNES)</th>
<th>REMARKS AND ASSUMPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging: Cardboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Boxes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Sheet or Film</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Polystyrene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Pallets or Skids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Crates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Paint Cans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Pails</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site-Clearing Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masonry or CMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Cut-Offs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Warped Pieces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood or OSB (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Waste Chutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim (cut-offs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Sealant Tubes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gypsum Board (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet and Pad (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Insert units of measure.
## FORM CWM-2: DEMOLITION WASTE IDENTIFICATION

<table>
<thead>
<tr>
<th>MATERIAL DESCRIPTION</th>
<th>EST. QUANTITY</th>
<th>EST. VOLUME CY (CM)</th>
<th>EST. WEIGHT TONS (TONNES)</th>
<th>REMARKS AND ASSUMPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphaltic Concrete Paving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood and OSB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Paneling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doors and Frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acoustical Tile</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet Pad</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demountable Partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabinets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping Supports and Hangers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper Wiring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Ballasts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchgear and Panelboards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## FORM CWM-3: CONSTRUCTION WASTE REDUCTION WORK PLAN

<table>
<thead>
<tr>
<th>MATERIAL CATEGORY</th>
<th>GENERATION POINT</th>
<th>TOTAL EST. QUANTITY OF WASTE TONS (TONNES)</th>
<th>DISPOSAL METHOD AND QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EST. AMOUNT SALVAGED TONS (TONNES)</td>
</tr>
<tr>
<td>Packaging: Cardboard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Boxes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Sheet or Film</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Polystyrene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Pallets or Skids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Crates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Paint Cans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Pails</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site-Clearing Waste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masonry or CMU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Cut-Offs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Warped Pieces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood or OSB (scraps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Forms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Waste Chutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim (cut-offs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Sealant Tubes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gypsum Board (scraps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet and Pad (scraps)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Form CWM-4: Demolition Waste Reduction Work Plan

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Generation Point</th>
<th>Total Est. Quantity of Waste Tons (Tonnes)</th>
<th>Disposal Method and Quantity</th>
<th>Handling and Transportation Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphaltic Concrete Paving</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood and OSB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Paneling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doors and Frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acoustical Tile</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet Pad</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demountable Partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabinets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supports and Hangers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper Wiring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Ballasts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchgear and Panelboards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## FORM CWM-7: CONSTRUCTION WASTE REDUCTION PROGRESS REPORT

<table>
<thead>
<tr>
<th>MATERIAL CATEGORY</th>
<th>TOTAL QUANTITY OF WASTE TONS (TONNES) (A)</th>
<th>QUANTITY OF WASTE SALVAGED (ESTIMATED TONS (TONNES) (B))</th>
<th>QUANTITY OF WASTE RECYCLED (ESTIMATED TONS (TONNES) (C))</th>
<th>TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)</th>
<th>TOTAL QUANTITY OF WASTE RECOVERED % (D / A x 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging: Cardboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Boxes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Sheet or Film</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Polystyrene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Pallets or Skids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Crates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Paint Cans</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging: Plastic Pails</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site-Clearing Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masonry or CMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Cut-Offs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber: Warped Pieces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood or OSB (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Forms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Waste Chutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim (cut-offs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Sealant Tubes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gypsum Board (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet and Pad (scraps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATERIAL CATEGORY</td>
<td>GENERATION POINT</td>
<td>TOTAL QUANTITY OF WASTE TONS (TONNES) (A)</td>
<td>QUANTITY OF WASTE SALVAGED</td>
<td>QUANTITY OF WASTE RECYCLED</td>
<td>TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------</td>
<td>------------------------------------------</td>
<td>----------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------------</td>
</tr>
<tr>
<td>Asphaltic Concrete Paving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood and OSB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Paneling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Trim</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Metals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doors and Frames</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acoustical Tile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpet Pad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demountable Partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabinets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supports and Hangers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conduit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper Wiring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Fixtures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Ballasts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchgear and Panelboards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION 01 77 00
CLOSEOUT PROCEDURES

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:

1. Substantial Completion procedures, including Notice of Completion and Final Inspection procedures.
2. Occupancy procedures, including Notice of Approval of Occupancy/Use and University Supplemental Notice of Occupancy and Use List.
3. Final Acceptance procedures, including Pre-Acceptance Checklist and University Supplemental Building/Project Acceptance List.
4. Inspections after completion.
5. Warranties.
6. Final cleaning.
7. Repair of the Work.

B. Related Requirements:

1. Section 01 32 33 "Photographic Documentation" for submitting final completion construction photographic documentation.
2. Section 01 73 00 "Execution" for progress cleaning of Project site.
3. Section 01 78 23 "Operation and Maintenance Data" for operation and maintenance manual requirements.
4. Section 01 78 39 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
5. Section 01 79 00 "Demonstration and Training" for requirements for instructing University's personnel.

1.3 ACTION SUBMITTALS
A. Product Data: For cleaning agents.

B. Contractor's List of Incomplete Items: Initial submittal at Notice of Completion.

C. Certified List of Incomplete Items: Final submittal at Final Acceptance.

1.4 CLOSEOUT SUBMITTALS
A. Certificates of Release: From authorities having jurisdiction.

B. Certificate of Insurance: For continuing coverage.
C. Field Report: For pest control inspection.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Schedule of Maintenance Material Items: For maintenance material submittal items specified in other Sections.

1.6 NOTICE OF COMPLETION AND SUBSTANTIAL COMPLETION PROCEDURES

A. Procedures and Submittals Prior to Notice of Completion: Complete and submit all of the following items prior to submitting Notice of Completion to Architect/Engineer. Include Contractor’s comprehensive list of items to be completed, corrected or not in compliance with the Drawings and Specifications.

1. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's preliminary punch list), indicating the value of each item on the list and reasons why the Work is incomplete.
2. Building Inspection Record: Submit completed record with all required corrections noted.
4. Final Completion Schedule: Submit schedule for performing and completing all work indicated on the Contractor’s list of incomplete items.
5. Submit sustainable design documentation.
6. Submit closeout submittals specified in other Division 01 Sections, including project record documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
7. Submit closeout submittals specified in individual Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
8. Submit test/adjust/balance records.

B. Final Inspection: Submit Notice of Completion to Architect/Engineer. Upon receipt, Architect/Engineer and University will review and if all items on the University Supplemental Notice of Completion Checklist are complete will, within the timeframe required by the Contract, schedule and make an inspection of the Project to determine whether the Work is substantially complete.

1. Final Punch List: Based on the inspection, Architect/Engineer will prepare a final punch list of work to be completed, work not in compliance with the Drawings or Specifications, and unsatisfactory work for any reason.
2. Re-inspection: If the cumulative number of items identified on the final punch list prevents a determination that the work is substantially complete, complete those items and when complete resubmit Notice of Completion. Upon receipt of resubmittal, Architect/Engineer and University will then schedule and make a re-inspection of the Project to determine whether the Work is substantially complete.

C. Notice of Substantial Completion: When inspection of the Work indicates that the Project is substantially complete and all other Contract provisions required for substantial completion have been satisfied, Architect/Engineer will issue a Notice of Substantial Completion (State Form SBP-07).
1.7 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Organize list of spaces in sequential order, starting with exterior areas first and proceeding from lowest floor to highest floor or as approved by Architect/Engineer.
2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Include the following information at the top of each page:
   a. Project name.
   b. Date.
   c. Name of Architect/Engineer.
   d. Name of Contractor.
   e. Page number.

4. Submit list of incomplete items in the following format:
   a. MS Excel and PDF electronic file. Architect/Engineer will return annotated file.

1.8 OCCUPANCY PROCEDURES

A. Procedures and Submittals Prior to Occupancy: Complete and submit all items on both State Form SBP-01 “Notice of Approval of Occupancy/Use” and University Supplemental Notice of Occupancy and Use List.

1.9 FINAL ACCEPTANCE PROCEDURES

A. Procedures and Submittals Prior to Final Acceptance: Complete and submit all items on both State Form SBP-05 “Pre-Acceptance Checklist” and University Supplemental Building/Project Acceptance List.

B. Inspection: Submit a written request for final inspection to determine acceptance a minimum of 10 business days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Architect/Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect/Engineer will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.10 SETTLEMENT AND FINAL PAYMENT

A. Submit and complete all of the following as a condition precedent to settlement and final payment:

1. All guarantees and warranties.
2. All statement to support local sales tax refunds, if any.
3. Three (3) sets of operation and maintenance manuals.
4. One (1) set of as-built Contract Documents showing all job changes.
5. All demonstration and training completed in accordance with Section 01 79 00.
CLOSEOUT PROCEDURES

6. All punch list items documented as complete.

B. Final Certificate of Payment: Submit in accordance with the requirements of Section 01 29 00 “Payment Procedures.”

1.11 INSPECTIONS AFTER COMPLETION

A. Warranty/Guarantee Inspections: During the warranty period, accompany Architect/Engineer and University Representative, and participate in inspection(s) of the Project to identify defective and deficient work at intervals and as required by the Contract.

B. List of Deficient or Defective Work: Within 10 business days of inspection, Architect/Engineer will provide Contractor with a list of items requiring correction.

C. Remedial Work: Upon receive of itemized list, immediately correct and remedy deficiencies and defects in a manner satisfactory to the Architect/Engineer and University.

1.12 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties to the Architect/Engineer prior to advertisement of the Notice of Contractor's Settlement. If the Notice of Acceptance designates a commencement date for warranties other than the date of Notice of Acceptance for the Work, or a designated portion of the Work, submit written warranties upon request of the Architect.

B. Partial Occupancy: When a designated portion of the Work is completed and occupied or used by the University, by separate agreement with the Contractor during the construction period, submit properly executed warranties to the Architect/Engineer within fifteen (15) calendar days of completion of that designated portion of the Work.

C. Special Warranties: When a special warranty is required to be executed by the Contractor, or the Contractor and a Subcontractor, supplier or manufacturer, prepare a written document that contains appropriate terms and identification, ready for execution by the required parties. Submit a draft to the University through the Architect/Engineer for approval prior to final execution. Refer to individual Specification Sections for specific requirements for special warranties.

D. Form of Submittal: Organize warranty documents into an orderly sequence based on the table of contents of Project Manual.

1. Number of Copies: Two.
2. Bind warranties and bonds in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
3. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
4. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.
5. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at beginning of document.

E. Provide additional copies of each warranty to include in operation and maintenance manuals.
F. List of Extended Warranties: Provide a comprehensive list of all manufacturers’ standard and special warranties with duration greater than one year after Notice of Acceptance. Organize list into an orderly sequence based on table of contents of the Project Manual.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

1. Use cleaning products that comply with Green Seal's GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.
2. Do not use sweeping compounds on concrete floors that will leave residue affecting finish floor materials.

PART 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations immediately prior to Occupancy for entire Project or for a designated portion of Project:

a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
d. Remove tools, construction equipment, machinery, and surplus material from Project site.
e. Remove snow and ice to provide safe access to building.
f. Clean exposed exterior and interior finishes to a dirt-free condition, free of grease, dust, stains, films, fingerprints, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
h. Sweep concrete floors broom clean in unoccupied spaces.
i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
j. Power scrub and power buff resilient flooring surfaces, tile and fluid-applied flooring.
k. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
CLOSEOUT PROCEDURES

1. Remove labels that are not permanent.

m. Wipe surfaces of mechanical and electrical equipment, elevator equipment where applicable, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.

n. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.

o. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.

p. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.


q. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.

r. Clean food service equipment to sanitary condition acceptable for intended food service use and approved by authority having jurisdiction.

s. Leave Project clean and ready for occupancy.

C. Pest Control: Comply with pest control requirements in Section 01 50 00 "Temporary Facilities and Controls." Prepare written report.

3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.

2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

3.3 ATTACHMENTS

A. Samples of the following forms are appended to this Section for reference following End of Section 01 77 00:

1. University of Colorado Denver | Anschutz Medical Campus Supplemental Notice of Occupancy and Use List.
2. University of Colorado Denver | Anschutz Medical Campus Supplemental Building / Project Acceptance List.

END OF SECTION 01 77 00
### Supplemental Notice of Occupancy and Use List 9/22/11 update (Clean)

**Project Name & Number:**

**Contractor:**

In addition to completing Notice of Approval of Occupancy / Use (SBP-01), the following items must be completed before Occupancy is approved.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date Completed</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Final and formal address posted on the building entries.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>2. A copy of the Contractor's in-progress red line &quot;as-built&quot; drawings has been given to BMO representative &amp; a 2nd copy is provided for Projects plan room. This is to include landscape drawings showing irrigation installation.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>3. Maintenance, operations and spare parts manuals on all installed equipment.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>4. Notice of Partial Substantial Completion concerning roles/ responsibilities of University and Contractor for security, maintenance, heat, utilities reviewed and accepted.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>5. Manufacturer maintenance, operations and spare parts manuals for fixtures, mechanical, electrical and plumbing.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>6. Hardware maintenance, operations and spare parts manuals for doors &amp; locks, including roll up doors.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>7. Warranty Dates and Contact list for all Contractors and Suppliers given to BMO.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>8. Transfer utility account from Contractor to Facilities Operations.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>9. Site plan to include first floor main isolation locations and plans for each floor to include main utility shutoffs, for utilities to include water, electrical, steam, sewer, fuel supply, telecom, fiber optic and gasses, identified on a set of drawings.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>10. If Commissioning Report is completed, BMO has reviewed/ commented, including electrical, plumbing, mechanical/ HVAC.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>11. All Contractor provided equipment has new filters &amp; construction filters removed.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>12. Not Used</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>13. Elevator equipment rooms insulated and space conditioned for control system requirements.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>14. Testing Certifications provided to BMO for Elevators, Fire Systems &amp; Annunciator Systems.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>15. FSS has been provided with copy of Building Department testing and inspection report for window washing equipment.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>16. Roof walking pads to access equipment are installed.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td>17. PM to communicate to fire department via Life Safety Officer that building has transitioned to BMO. Alarms at Anschutz Medical Campus report to University Police Dispatch and at Downtown report to designated monitoring company.</td>
<td></td>
<td>CLOSED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>18.</td>
<td>BAS System (Siemens), Energy and Lighting, Fuel Systems, and Power Management must report remotely &amp; verify with University - Engineering.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>19.</td>
<td>Training for BMO and FSS on installed equipment and systems is completed.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>20.</td>
<td>Equipment keys and locks transitioned to Operations, including fire panels, electrical panels, directories and generator panels. Construction cores removed and replaced with permanent cores.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>21.</td>
<td>Access control pathways and junction boxes for installed doors, gates, loading docks and roof access complete. <em>All wiring and hardware completed and electronic security access controls in place and tested by University Electronic Security.</em></td>
<td>CLOSED</td>
</tr>
<tr>
<td>22.</td>
<td>EH&amp;S is provided, as applicable for project, with fume hood certification, water testing certification, hazardous waste compliance certification, radiation compliance certification, BSL3 certification, and all other specialty equipment certification.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>23.</td>
<td>PM notifies University Risk Management that project is transferring to University and notifies Contractor that it can eliminate Builders Risk Insurance.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>24.</td>
<td>Not Used</td>
<td>CLOSED</td>
</tr>
<tr>
<td>25.</td>
<td>Not Used</td>
<td>CLOSED</td>
</tr>
<tr>
<td>26.</td>
<td>Elevator tools, including hand tools, computer, proprietary and operational software is received and confirm 1-year service from date of acceptance.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>27.</td>
<td>All computers and software required in drawings and specs. are received, including for BAS, Energy and Lighting, Fuel Systems, and Power Management, and any specialty software and alarm codes for operating systems.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>28.</td>
<td>For all areas to be transferred to University, all waste and debris removed; floor and wall surfaces clean and in good repair; ceiling surfaces clean, unmarked, in place; site, including sidewalks, cleared of debris and construction equipment; and roof is clear of all materials and debris.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>29.</td>
<td>Water chlorination and testing complete and provided by PM to Chief Building Official and BMO via BMO Rep.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>30.</td>
<td>Toilet accessories are in place that meet custodial contract.</td>
<td>CLOSED</td>
</tr>
<tr>
<td>31.</td>
<td>Trash receptacles outside the building are in place.</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>

*Highlighted items are not the responsibility of Contractor but PM and BMO Rep must ensure these are completed and operational prior to occupancy and use.*

Mark N/A by item if it is not applicable to project

7.12.11
## Supplemental Building / Project Acceptance List

### 9/22/11 Update (Clean)

**Project Name & Number:**

**Contractor:**

In addition to completing Pre-Acceptance Checklist (SBP-05), the following items must be completed before Final Acceptance.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date Completed</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Review State Buildings Pre-Acceptance check list &amp; Notice of Approval of Occupancy / use form with BMO rep &amp; confirm agreement with status</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>2. Establish list of post construction change orders &amp; track separately from basic project until items are complete – call it Phase 2 to avoid delay on basic project</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>3. O &amp; M Manuals given to BMO Representative and BMO Archivist (2 hard copies and 1 electronic total)</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>4. Record Documents – a hard copy of plans and specifications are provided for plan room &amp; given to BMO &amp; electronic auto cad &amp; specs are given to Archive Officer (Art Steinman) this is to include landscape drawings showing irrigation installation.</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>5. Final Site Walk is completed with University Grounds Supervisor. Drain barriers are removed and storm drains cleared. MS4 storm water plan, CDPHE permits, and evidence of final closeout received by Project Manager and all copied to University Engineering Division.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>6. Move-related work items complete including physical move, tours (occupants &amp; police), mail, phone &amp; electrical hook ups for equipment &amp; furniture systems complete &amp; freezers enrolled in University freezer program.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>7. If exterior work is applicable: Landscape – Include a walk through with University Grounds for 1) new &amp; established 1-year service date; 2) existing damaged landscape is repaired; and 3) irrigation – zone control test is complete.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>8. Attic stock, matches spec. requirements, is located in secured location, and is inventoried.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>9. Electrical system one line diagram framed and mounted in electrical room.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>10. Spare fire suppression heads in cabinets and tool: cabinet in main electrical room includes one complete set of spare fuses for major equipment.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>11. Contractor keys issued by University BMO returned to University Key Shop via PM/BMO Rep.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>12. Interior Finishes Binder given to the University Project Manager: (Two hard copies)</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>13. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>14. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>15. Safety grating in pipe chases in place.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>16. Signs in place including monument sign, building exterior and site signage and building interior signage.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>17. All applicable reports, including Air Emission reports; Sewer Reports, including for process diverters, traps and collection tanks; Fuel Storage Tank and Detection reports; and Water System tests and reports provided to BMO via PM and BMO Rep.</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>18. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>19. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>20. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>21. Not Used</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>22. If commissioning is included for project, Commissioning Agent certification is received by BMO via PM and BMO Rep.</td>
<td>CLOSED</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University Project Manager (sign &amp; print name)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>University FSS (sign &amp; print name)</td>
<td>Date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>University BMO Rep. (sign &amp; print name)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>University Downtown Rep (if necessary) (sign &amp; print name)</td>
<td>Date</td>
</tr>
</tbody>
</table>

*Warranty dates are not subject to completion of these items by contract
** Highlighted items are not the responsibility of Contractor but PM and BMO Rep must ensure these are completed and operational prior to occupancy and use.
Mark N/A by item if it is not applicable to project
7.12.11
SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
   1. Operation and maintenance documentation directory.
   2. Systems, subsystems, and equipment operation and maintenance manuals.
   3. Product maintenance manuals.
   4. Emergency manuals.
   5. Framed operating and maintenance instructions.

B. Related Requirements:
   1. Section 01 33 00 "Submittal Procedures" for submitting copies of submittals for operation and maintenance manuals.
   2. Section 01 91 13 "General Commissioning Requirements" for verification and compilation of data into operation and maintenance manuals.

1.3 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 CLOSEOUT SUBMITTALS

A. Schedule: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 30 calendar days before commencing demonstration and training. Architect/Engineer will return copy with comments.
   1. Correct or revise each manual to comply with Architect/Engineer's comments. Submit copies of each corrected manual within 15 calendar days of receipt of Architect/Engineer's comments and prior to commencing demonstration and training.

B. Format: Submit operations and maintenance manuals in the following format:
1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Architect/Engineer.
   a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.
   b. Compile entirely from documents with searchable text.
   c. Enable inserted reviewer comments on draft submittals.

2. Paper copies. Assemble in accordance with the requirements of this Section.
   a. Submit three final copies, one to be retained by the Architect/Engineer and two to be retained by the University.

C. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 30 calendar days before commencing demonstration and training. Architect/Engineer will return copy with comments.

1. Correct or revise each manual to comply with Architect/Engineer's comments. Submit copies of each corrected manual within 15 calendar days of receipt of Architect/Engineer's comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

Retain "Operation and Maintenance Documentation Directory" Article below only for Large Projects.

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information. Include a section in the directory for each of the following:

1. List of documents.
2. List of systems.
3. List of equipment.
4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."
2.2 GENERAL REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Intent: Prepare data in form of an instructional manual for use by University personnel.

B. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.

C. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of University.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect/Engineer.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Architect/Engineer that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

D. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

E. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

F. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

G. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

Retain "Manuals, Electronic Files" Paragraph for Large Projects.

H. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.
1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size and enable OCR (optical character recognition) to provide searchable text.

2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

Retain "Manuals, Paper Copy" Paragraph for both Large and Small Projects.

I. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in minimum 1 inch and maximum 2 inch thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
   a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
   b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents, and indicate Specification Section number on bottom of spine. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.

3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.


5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.3 SYSTEMS, SUBSYSTEMS AND EQUIPMENT OPERATION AND MAINTENANCE MANUALS

A. General: Provide operation and maintenance manuals where indicated in individual Specification Section and the following:

1. Heating, ventilating and air-conditioning equipment and systems.
2. Plumbing equipment and systems.
3. Special piping equipment and systems.
4. Electrical distribution systems.
5. Standby generator systems.
6. Communications systems.
7. Fire alarm and detection systems.
8. Underground sprinkler systems.
10. Food service equipment.
11. Elevators.
12. Other special construction and conveying systems.

B. Operation Content: In addition to requirements in this Section, include operation data required in individual Specification Sections.

1. Additional Operation Content Required:
   b. Performance and design criteria if Contractor has delegated design responsibility.
   c. Operating standards.
   d. Operating procedures.
   e. Operating logs.
   f. Wiring diagrams.
   g. Control diagrams.
   h. Piped system diagrams.
   i. Precautions against improper use.
   j. License requirements including inspection and renewal dates.

2. Descriptions: Include the following:
   a. Product name and model number. Use designations for products indicated on Contract Documents.
   b. Manufacturer's name.
   c. Equipment identification with serial number of each component.
   d. Equipment function.
   e. Operating characteristics.
   f. Limiting conditions.
   g. Performance curves.
   h. Engineering data and tests.
   i. Complete nomenclature and number of replacement parts.

3. Operating Procedures: Include the following, as applicable:
   a. Startup procedures.
   b. Equipment or system break-in procedures.
   c. Routine and normal operating instructions.
   d. Regulation and control procedures.
   e. Instructions on stopping.
   f. Normal shutdown instructions.
   g. Seasonal and weekend operating instructions.
   h. Required sequences for electric or electronic systems.
   i. Special operating instructions and procedures.

4. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

C. Maintenance Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

1. Source Information: Provide the following information in a list for each product included in manual:
   a. Name, address, and telephone number of Installer or supplier and maintenance service agent.
   b. Name, address, and telephone number of local source for supply of replacement parts.
   c. Name, address, and telephone number of maintenance contractor, where appropriate.
   d. Cross-reference Specification Section number and title.
   e. Drawing or schedule designation or identifier where applicable.

2. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
   a. Standard maintenance instructions and bulletins.
   b. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, repair, and assembly.
   c. Identification and nomenclature of parts and components.
   d. List of items recommended to be stocked as spare parts.

3. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
   a. Test and inspection instructions.
   b. Troubleshooting guide.
   c. Precautions against improper maintenance.
   d. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   e. Aligning, adjusting, and checking instructions.
   f. Demonstration and training video recording, if available.

4. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
   a. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
   b. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

5. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

6. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

7. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
   a. Include procedures to follow and required notifications for warranty claims.
   b. Include information sheet covering proper procedures in event of failure and instances which might affect validity of warranties and bonds.
2.4 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Separate into two manuals: one for exterior moisture protection products and those exposed to weather and one for interior products. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: Provide the following information for each product included in manual:
   1. Name, address, and telephone number of Installer or supplier and maintenance service agent.
   3. Drawing or schedule designation or identifier where applicable.

C. Product Information: Include the following, as applicable:
   1. Product name and model number.
   2. Manufacturer's name.
   3. Color, pattern, and texture.
   5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
   1. Inspection procedures.
   2. Types of cleaning agents to be used and methods of cleaning.
   3. List of cleaning agents and methods of cleaning detrimental to product.
   4. Schedule for routine cleaning and maintenance.
   5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
   1. Include procedures to follow and required notifications for warranty claims.

2.5 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:
   1. Type of emergency.
   2. Emergency instructions.
   3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:
   1. Fire.
   2. Flood.
   5. Power failure.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of University's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

2.6 FRAMED OPERATING AND MAINTENANCE INSTRUCTIONS

A. All mechanically and electrically operated equipment and controls shall be provided with legible and complete wiring diagrams, schematics, operating instructions, and pertinent preventative maintenance instructions in a sturdy frame with clear glass or plastic cover. Use non-fading, permanent media.

B. Locate frames in the same room or service enclosure as equipment, or in the nearest mechanical or electrical room.

PART 3 - EXECUTION (Not Used)
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for project record documents, including the following:

1. Record Drawings.
2. Record Specifications.
3. Record Product Data.
4. Record Samples.
5. Miscellaneous record submittals.

B. Related Requirements:

1. Section 01 73 00 "Execution" for final property survey.
2. Section 01 77 00 "Closeout Procedures" for general closeout procedures.
3. Section 01 78 23 "Operation and Maintenance Data" for operation and maintenance manual requirements.

1.3 CLOSEOUT SUBMITTALS

A. General: Submit record drawings with duplicate original transmittal letters containing:

1. Date.
2. Project title and number.
3. Contractor’s name and address.
4. Certification that each document as submitted is complete and accurate.
5. Signature of authorized representative of the Contractor.

B. Record Drawings: Submit copies of record Drawings as follows:

1. Submit three paper-copy sets of marked-up record prints, two copies will be retained by the University and one copy retained by the Architect/Engineer.
2. Submit three paper-copy sets and three digital copies on CD of electronic files for all delegated-design submittals. Two copies will be retained by the University and one copy retained by the Architect/Engineer.

C. Record Specifications: Submit three paper copies of Project's Specifications, including addenda and contract modifications. Two copies will be retained by the University and one copy retained by the Architect/Engineer.
D. Record Product Data: Submit three paper copies of each submittal. Two copies will be retained by the University and one copy retained by the Architect/Engineer.
   
   1. Where record Product Data are required as part of operation and maintenance manuals, submit duplicate marked-up Product Data as a component of manual.

E. Miscellaneous Record Submittals: See other Specification Sections for miscellaneous record-keeping requirements and submittals in connection with various construction activities. Submit three paper copies of each submittal. Two copies will be retained by the University and one copy retained by the Architect/Engineer.

F. Interior Finishes Binder: Three copies. Two copies will be retained by the University and one copy retained by the Architect/Engineer.

PART 2 - PRODUCTS

2.1 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised drawings as modifications are issued.

   1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.

      a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
      b. Accurately record information in an acceptable drawing technique.
      c. Record data as soon as possible after obtaining it.
      d. Record and check the markup before enclosing concealed installations.
      e. Cross-reference record prints to corresponding archive photographic documentation.
      f. Mark using line types and symbols conforming to Contract Documents.

   2. Content: Types of items requiring marking include, but are not limited to, the following:

      a. Dimensional changes to Drawings.
      b. Revisions to details shown on Drawings.
      c. Depths of foundations below first floor.
      d. Locations and depths of underground utilities referenced to permanent surface improvements.
      e. Revisions to routing of piping and conduits.
      f. Revisions to electrical circuitry.
      g. Actual equipment locations.
      h. Duct size and routing.
      i. Locations of concealed internal utilities referenced to visible and accessible features of structure.
      j. Locations of concealed valves, dampers, controls, balancing devices, junction boxes, cleanouts, and other items requiring access or maintenance.
      k. Changes made by Change Order.
      l. Changes made following Architect/Engineer's written orders.
      m. Details not on the original Contract Drawings.
      n. Field records for variable and concealed conditions.
Record information on the Work that is shown only schematically.

3. Mark the Contract Drawings and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.

4. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.

5. Mark additional information important to University that was either shown schematically or omitted from original Drawings.

6. Note Change Order numbers, and similar identification, where applicable.

B. Record Delegated Design Electronic Files: For all delegated design submittals, including but not limited to landscape irrigation, fire alarm and fire sprinkler plans, prepare electronic files in full compliance with University of Colorado Denver | Anschutz Medical Campus Guidelines and Design Standards, Part 1.0, Paragraph “Drawing Production Standards.”

C. Identification: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

1. Record Prints: Organize record prints into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.

2. Identification: As follows:
   a. Project name.
   b. Date.
   c. Designation "PROJECT RECORD DRAWINGS."
   d. Name of Architect/Engineer.
   e. Name of Contractor.

2.2 RECORD SPECIFICATIONS

A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.

1. Give particular attention to substitutions, selection of options, and similar information on concealed products and installations that cannot be readily identified and recorded later.

2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.

3. Note related Change Orders where applicable.

4. Maintain one complete copy of all Addenda, Change Orders and other written change documents in printed form during construction.

2.3 RECORD PRODUCT DATA

A. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.

2. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.

3. Note related Change Orders, record Specifications, and record Drawings where applicable.

B. Directory: Include record Product Data directory organized by Specification Section number and title.
C. Product List: Update and record any changes to Product List submitted in accordance with Section 01 60 00 “Product Requirements”, including any changes to brand, model, subcontractor, or Installer so that final list reflects materials, equipment and systems incorporated into the Work.

2.4 RECORD SAMPLES

A. Prior to Final Acceptance, meet with University Project Manager and Architect/Engineer at site to review and identify which submitted samples maintained during the progress of the Work are to be transmitted to the University.

B. Deliver selected samples to storage area identified by University.

C. Finishes Binder: Three-ring notebook or notebooks, organized by Specification Section number, providing a listing and description of all material finishes on the Project and including a minimum 6 inch by 6 inch sample thereof to accompany the description. Accompany each material selection indicated with the following:

1. Manufacturer and product name.
2. Pattern name and number, as applicable.
3. Color name, as applicable.
4. Any additional information required to order replacement product.

2.5 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

1. Include manufacturer’s certifications, field test record, copies of permits, licenses, certifications, inspection reports, releases, notices, receipts for fee payments and similar documents.

B. Directory: Include miscellaneous record submittals directory organized by Specification Section number and title.

PART 3 - EXECUTION

3.1 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project. Update at least weekly.

B. Maintenance of Record Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to project record documents for Architect/Engineer’s and University’s reference during normal working hours.

END OF SECTION 01 78 39
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes descriptions and quantities of required extra stock materials.

1.3 INFORMATIONAL SUBMITTALS
   A. Schedule of Maintenance Materials: Prepare a schedule in tabular form of all extra stock materials required in individual Specification Sections including:
      1. Specification Section number and title.
      2. Description of required material
      3. Quantity of required material.

1.4 MAINTENANCE MATERIALS
   A. Furnish extra materials that match and are from the same production runs as the product installed.
   B. Provide in the quantities indicated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 MAINTENANCE MATERIAL SCHEDULE

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>04 42 00</td>
<td>EXTERIOR STONE CLADDING</td>
<td>Dimension Stone Units</td>
<td>Furnish 100 sq. ft. finished stone panels for each finish and variety of stone specified.</td>
</tr>
<tr>
<td>09 30 00</td>
<td>TILING</td>
<td>Tile and Trim Units</td>
<td>Furnish 100 sq. ft. of full-size units for each type, composition, color, pattern, and size indicated.</td>
</tr>
<tr>
<td>----------</td>
<td>--------</td>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>09 30 33</td>
<td>STONE TILING</td>
<td>Dimension Stone Tile</td>
<td>Furnish 100 sq. ft. of full-size units for each type, composition, color, pattern, and size indicated.</td>
</tr>
<tr>
<td>09 51 13</td>
<td>ACOUSTICAL PANEL CEILINGS</td>
<td>Acoustical Ceiling Panels</td>
<td>100 sq. ft. of full-size panels.</td>
</tr>
<tr>
<td>09 51 23</td>
<td>ACOUSTICAL TILE CEILINGS</td>
<td>Acoustical Ceiling Units</td>
<td>100 sq. ft. of full-size tiles.</td>
</tr>
<tr>
<td>09 54 36</td>
<td>SUSPENDED DECORATIVE GRIDS</td>
<td>Suspended Decorative Grids</td>
<td>100 sq. ft. of each suspended decorative grid component, exposed molding, and trim.</td>
</tr>
<tr>
<td>09 62 29</td>
<td>CORK FLOORING</td>
<td>Cork Flooring</td>
<td>Furnish 1 box of each type, shade, pattern, and finish of cork flooring installed.</td>
</tr>
<tr>
<td>09 65 13</td>
<td>RESILIENT BASE AND ACCESSORIES</td>
<td></td>
<td>Furnish 50 linear feet of each type, color, pattern, and size of wall base installed. Furnish 2% of each type, color, pattern, and size of all other resilient accessories installed.</td>
</tr>
<tr>
<td>09 68 13</td>
<td>TILE CARPETING</td>
<td>Carpet Tile</td>
<td>100 sq. ft. of full-size units for each type indicated.</td>
</tr>
<tr>
<td>10 13 00</td>
<td>DIRECTORIES</td>
<td>Message Strips</td>
<td>Full-size, blank strips equal to 10 percent of amount installed for each size indicated, but no fewer than 20 strips.</td>
</tr>
<tr>
<td>11 12 00</td>
<td>PARKING CONTROL EQUIPMENT</td>
<td>Gate Arms</td>
<td>1 breakaway gate arms for each gate installed, complete with accessory components.</td>
</tr>
<tr>
<td>12 21 13</td>
<td>HORIZONTAL LOUVER BLINDS</td>
<td>Horizontal Louver Blinds</td>
<td>Full-size units equal to 1 percent of quantity installed for each size, color, texture, pattern, and gloss indicated, but no fewer than two units and no more than five units.</td>
</tr>
<tr>
<td>14 20 00</td>
<td>ELEVATORS</td>
<td></td>
<td>2 sets of complete parts catalogs including manufacturer’s recommended spare parts list with clear identification and illustration of each functional part, exploded parts views, identification of part numbers and assembly numbers including replaceable electrical and electronic parts and circuit boards.</td>
</tr>
<tr>
<td>21 05 00</td>
<td>FIRE SUPPRESSION</td>
<td>Sprinkler heads and Special Sprinkler Wrenches.</td>
<td>2 heads minimum of each type and temperature rating installed and special sprinkler wrenches enclosed in a steel cabinet in accordance with NFPA 13.</td>
</tr>
<tr>
<td>22 30 00</td>
<td>PLUMBING EQUIPMENT</td>
<td>Valve Key</td>
<td>1 valve key for each key operated wall hydrant, post hydrant, hose bib, or faucet installed.</td>
</tr>
<tr>
<td>23 05 13</td>
<td>MOTORS</td>
<td>Variable Frequency Drives</td>
<td>1 complete set of spare fuses for each VFD supplied.</td>
</tr>
<tr>
<td>23 30 00</td>
<td>HVAC AIR DISTRIBUTION</td>
<td>Fire Dampers</td>
<td>3 fusible links per type installed.</td>
</tr>
<tr>
<td>23 57 00</td>
<td>HEAT EXCHANGERS FOR HVAC</td>
<td>Heat Exchanger</td>
<td>1 gasket for each flanged connection for each heat exchanger installed.</td>
</tr>
<tr>
<td>Code</td>
<td>Category</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>23 65 00</td>
<td>COOLING TOWERS</td>
<td>3 spray nozzles for each tower cell provided.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 gasket for each gasketed access and inspection opening provided.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 set of matched fan belts for each belt driven fan provided.</td>
<td></td>
</tr>
<tr>
<td>23 70 00</td>
<td>CENTRAL HVAC EQUIPMENT</td>
<td>Air Handling Units</td>
<td>1 complete set of filters for each air-handling unit installed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 set of belts for each unit installed with label clearly identifying to which fan the belt belongs.</td>
<td></td>
</tr>
<tr>
<td>26 09 43</td>
<td>NETWORK LIGHTING CONTROLS</td>
<td>Control Devices</td>
<td>3 devices for each device used.</td>
</tr>
<tr>
<td>26 20 00</td>
<td>LOW VOLTAGE ELECTRICAL DISTRIBUTION</td>
<td>Fuses</td>
<td>1 set of 3 of each type and size used on the project and fuse cabinet in main electrical room to hold them.</td>
</tr>
<tr>
<td>26 51 00</td>
<td>INTERIOR LIGHTING</td>
<td>Lamps</td>
<td>Provide 5% or a maximum of 25 spares of each lamp type used on the project.</td>
</tr>
<tr>
<td>28 31 00</td>
<td>FIRE DETECTION AND ALARM</td>
<td>Initiating and Control Devices</td>
<td>Provide 5 spare devices for each device type used.</td>
</tr>
<tr>
<td></td>
<td>Notification Devices</td>
<td></td>
<td>Provide 5 spare devices for each device type used.</td>
</tr>
</tbody>
</table>

END OF SECTION 01 78 46
SECTION 01 79 00

DEMONSTRATION AND TRAINING

Revise this Section by deleting and inserting text to meet Project-specific requirements. Coordinate with the University Project Manager.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

    A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

    A. Section includes administrative and procedural requirements for instructing University's personnel, including the following:

       1. Demonstration of operation of systems, subsystems, and equipment.
       2. Training in operation and maintenance of systems, subsystems, and equipment.

1.3 INFORMATIONAL SUBMITTALS

    A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include outline for each training module.

    B. Qualification Data: For instructor, demonstrating qualifications and ability to instruct on maintenance and care of system, equipment and products.

    C. Schedule of Demonstration and Training: Prepare a schedule in tabular form of all demonstration and training required in individual Specification Sections including:

       1. Specification Section number and title.
       2. Description of required demonstration and training.

    D. Attendance Record: For each training module, submit list of participants and length of instruction time.

1.4 QUALITY ASSURANCE

    A. Instructor Qualifications: A factory-authorized service representative, complying with requirements in Section 01 40 00 "Quality Requirements," experienced in operation and maintenance procedures and training. Manufacturer’s sales staff is not acceptable.

    B. Pre-instruction Conference: Conduct conference at Project site to comply with requirements in Section 01 31 00 "Project Management and Coordination." Review methods and procedures related to demonstration and training.
PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
   a. System, subsystem, and equipment descriptions.
   b. Performance and design criteria if Contractor is delegated design responsibility.
   c. Operating standards.
   d. Regulatory requirements.
   e. Equipment function.
   f. Operating characteristics.
   g. Limiting conditions.
   h. Performance curves.

2. Documentation: Review the following items in detail:
   a. Emergency manuals.
   b. Operations manuals.
   c. Maintenance manuals.
   d. Project record documents.
   e. Identification systems.
   f. Warranties and bonds.
   g. Maintenance service agreements and similar continuing commitments.

3. Emergencies: Include the following, as applicable:
   a. Instructions on meaning of warnings, trouble indications, and error messages.
   b. Instructions on stopping.
   c. Shutdown instructions for each type of emergency.
   d. Operating instructions for conditions outside of normal operating limits.
   e. Sequences for electric or electronic systems.
   f. Special operating instructions and procedures.
   g. A tour of the installation identifying the location of all system components.

4. Operations: Include the following, as applicable:
   a. Startup procedures.
   b. Equipment or system break-in procedures.
   c. Routine and normal operating instructions.
   d. Regulation and control procedures.
   e. Control sequences.
   f. Safety procedures.
   g. Instructions on stopping.
   h. Normal shutdown instructions.
   i. Operating procedures for emergencies.
   j. Operating procedures for system, subsystem, or equipment failure.
   k. Seasonal and weekend operating instructions.
1. Required sequences for electric or electronic systems.
2. Special operating instructions and procedures.
3. Sequence of operation.

5. Adjustments: Include the following:
   a. Alignments.
   b. Checking adjustments.
   c. Noise and vibration adjustments.
   d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:
   a. Diagnostic instructions.
   b. Test and inspection procedures.

7. Maintenance: Include the following:
   a. Inspection procedures.
   b. Types of cleaning agents to be used and methods of cleaning.
   c. List of cleaning agents and methods of cleaning detrimental to product.
   d. Procedures for routine cleaning
   e. Procedures for preventive maintenance.
   f. Procedures for routine maintenance.
   g. Instruction on use of special tools.

8. Repairs: Include the following:
   a. Diagnosis instructions.
   b. Repair instructions.
   c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   d. Instructions for identifying parts and components.
   e. Review of spare parts needed for operation and maintenance.
   f. Product support/service model.
   g. Purchasing of replacement parts.

9. Instruction specific to Instrumentation and Controls, Electrical Gateway, Network Lighting Controls, or any other new technology that is integrated with another system: Include the following:
   a. Overview and theory.
   b. Wiring diagrams, including the one line diagram.
   c. Creation, editing, and programming of the point database.
   d. Integration topology and platform for communication.
   e. Graphics packages and touch screens for the system.
   f. Alarms and diagnostics.
   g. Reporting functions dynamically and historically.
   h. Remote access to the system.
   i. Database back-up and maintenance.
   j. Replacement and re-programming of replacement parts.
   k. Point type and functionality for each type of point.
   l. Programming.
   m. Point/object editing.
   n. Loop tuning.
   o. Help files and other troubleshooting documentation.
Instruction is given by the staff that setup the integration.

C. Operation and Maintenance Manuals: Provide appropriate Operation and Maintenance manuals in each training session so that the detail drawings and maintenance activities are outlined and discussed for each application.

PART 3 - EXECUTION

3.1 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module.

B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

A. Engage qualified instructors to instruct University's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

   1. University will furnish Contractor with names and positions of participants.

B. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

   1. Coordinate schedule for all training with University Project Manager and provide the following:

      a. Minimum 3 weeks notification.
      b. Training matrix in calendar format.
      c. Training outline for each session.

   2. Do not schedule training until equipment has been started up, commissioned, and is currently operating in its normal condition.

   3. Do not schedule overlapping training sessions.

   4. Schedule training sessions for a maximum of 4 hours per day; afternoons preferred.

   5. Provide separate training session on each system for operational/maintenance groups and user groups.

   6. Training sessions will be cancelled and rescheduled unless the following documentation is received:

      a. Instruction qualifications.
      b. Evidence that equipment has been started up, commissioned, and is currently operating in its normal condition.
      c. Operation and Maintenance manuals.

C. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.

D. Travel, Room and Board: Coordinate any out-of-state training with the University Project Manager.

E. Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.
### DEMONSTRATION SCHEDULE

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 42 29.33</td>
<td>SWINGING AUTOMATIC ENTRANCES</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain automatic entrances.</td>
</tr>
<tr>
<td>10 11 00</td>
<td>VISUAL DISPLAY SURFACES</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain motor-operated, sliding visual display units.</td>
</tr>
<tr>
<td>10 22 38</td>
<td>OPERABLE PANEL PARTITIONS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain operable panel partitions.</td>
</tr>
<tr>
<td>10 55 00</td>
<td>POSTAL SPECIALTIES</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain postal specialties.</td>
</tr>
<tr>
<td>11 12 00</td>
<td>PARKING CONTROL EQUIPMENT</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain parking control equipment.</td>
</tr>
<tr>
<td>11 13 00</td>
<td>LOADING DOCK EQUIPMENT</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain loading dock equipment.</td>
</tr>
<tr>
<td>11 14 00</td>
<td>FOOD SERVICE EQUIPMENT</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain foodservice equipment.</td>
</tr>
<tr>
<td>11 82 26</td>
<td>FACILITY WASTE COMPACTORS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain waste compactors according to manufacturer's requirements and ANSI Z245.2.</td>
</tr>
<tr>
<td>12 21 13</td>
<td>HORIZONTAL LOUVER BLINDS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain systems.</td>
</tr>
<tr>
<td>12 24 13</td>
<td>ROLLER WINDOW SHADES</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain motor-operated roller shades.</td>
</tr>
<tr>
<td>13 20 00</td>
<td>SPECIAL PURPOSE ROOMS</td>
<td>Engage a factory-authorized service representative to train and provide training video to University’s maintenance personnel to operate, adjust, maintain, and repair controlled environmental rooms and cold rooms.</td>
</tr>
<tr>
<td>14 21 00</td>
<td>ELECTRIC TRACTION ELEVATORS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to operate, adjust, and maintain elevator(s).</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14 21 13</td>
<td>ELECTRIC TRACTION FREIGHT ELEVATORS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to operate, adjust, and maintain elevator(s).</td>
</tr>
<tr>
<td>14 24 00</td>
<td>HYDRAULIC ELEVATORS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to operate, adjust, and maintain elevator(s).</td>
</tr>
<tr>
<td>14 24 13</td>
<td>HYDRAULIC FREIGHT ELEVATORS</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to operate, adjust, and maintain elevator(s).</td>
</tr>
<tr>
<td>23 00 00</td>
<td>HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)</td>
<td>Schedule instructional meetings for The University of Colorado Denver Facilities Operations maintenance personnel on the proper operation and maintenance of mechanical systems. Provide the project manager a minimum of 5 days notice prior to any testing.</td>
</tr>
<tr>
<td>23 05 13</td>
<td>MOTORS</td>
<td>Engage a factory-authorized representative to train the University’s representative for 2 hours for each variable frequency drive installed. Training includes startup, shutdown, emergency operation, maintenance and servicing.</td>
</tr>
<tr>
<td>23 08 00</td>
<td>COMMISIONING OF HVAC</td>
<td>Engage the commissioning authority to provide a customized one to two day training class for the university’s engineering personnel in problem solving techniques including the review of mechanical system design as a whole, integrated unit, unique qualities of the installed mechanical system, insights into how to solve system-wide, multi-faceted problems, and identify a variety of resources to assist with problem solving.</td>
</tr>
<tr>
<td>23 09 00</td>
<td>INSTRUMENTATION AND CONTROLS</td>
<td>Engage a factory-authorized trained representative to conduct a minimum of 1-four hour on-site training course and an additional 1-four hour on-site training course per 25,000 sq. ft. for designated University personnel. Provide 40 hours of certified training in Instrument and Controls for every 100,000 sq. ft. of a lab/research building.</td>
</tr>
<tr>
<td>23 11 13</td>
<td>FACILITY FUEL-OIL PIPING</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain liquid-level gage systems, leak-detection and monitoring systems, and fuel-oil pumps.</td>
</tr>
<tr>
<td>23 21 23</td>
<td>PUMPS</td>
<td>Engage a factory-authorized service representative to train a University Representative for 2 hours of instruction for each pumping system provided.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>23 25 13</td>
<td>CHEMICAL WATER TREATMENT</td>
<td>Engage a factory-authorized service representative to train operating personnel for 8 hours to familiarize them with all treatment equipment and procedures. Include procedure for taking weekly water test on open-loop systems and the application and safe handling of supplied chemicals.</td>
</tr>
<tr>
<td>23 64 16</td>
<td>CENTRIFUGAL WATER CHILLERS</td>
<td>Engage a factory-authorized service representative to train the University’s representative for 4 hours including the operation of chillers, accessories and controls, procedures for startup and shutdown, troubleshooting, servicing, preventative maintenance, and review of the maintenance manuals.</td>
</tr>
<tr>
<td>23 65 00</td>
<td>COOLING TOWERS</td>
<td>Engage a factory-authorized service representative to train the University’s personnel for one, 8-hour day, for operation and maintenance of the cooling towers.</td>
</tr>
<tr>
<td>23 76 00</td>
<td>EVAPORATIVE COOLING EQUIPMENT</td>
<td>Engage the manufacturer’s representative to train the University’s personnel for four (4) hours. Include start-up and shutdown procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures, and the contents of the Operating and Maintenance Data.</td>
</tr>
<tr>
<td>26 00 00</td>
<td>ELECTRICAL</td>
<td>Engage a factory-authorized service representative to train the University’s Operations personnel a minimum of 8 hours for each system. Provide an additional minimum of 4 hours for any electrical gateway or networked lighting controls.</td>
</tr>
<tr>
<td>26 56 00</td>
<td>EXTERIOR LIGHTING</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain luminaire lowering devices.</td>
</tr>
<tr>
<td>28 31 00</td>
<td>FIRE DETECTION AND ALARM</td>
<td>Engage a factory-authorized service representative to train the University’s Operations personnel a minimum of 8 hours for each system.</td>
</tr>
<tr>
<td>32 84 00</td>
<td>PLANTING IRRIGATION</td>
<td>Engage a factory-authorized service representative to train University’s maintenance personnel to adjust, operate, and maintain automatic control valves and controllers.</td>
</tr>
</tbody>
</table>

END OF SECTION 01 79 00
SECTION 01 81 13 - SUSTAINABLE DESIGN REQUIREMENTS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Comply with State of Colorado High Performance Certification Program (HPCP).
      a. LEED Certification Level: At a minimum, achieve the level required by the HPCP at the commencement of the project.
      b. Design building enclosure, building interiors and building systems, and select materials consistent with and as required for achievement of the project LEED certification goal, including both prerequisites and credits.
   2. LEED Checklist: Prepare a checklist identifying credits to be achieved and demonstrating that the design, when complete, will obtain the required LEED certification level.
   3. Pursue Measurement + Verification credit for all buildings.

B. Performance Requirements:
   1. Energy Reduction: Design building to achieve the reduction of energy by cost method based on ASHRAE 90.1 required by the HPCP.

1.2 QUALITY ASSURANCE

A. LEED Coordinator: Require Contractor to engage an experienced LEED-Accredited Professional to manage the LEED compliance program during construction.

B. LEED Action Plan: Require Contractor to prepare and submit plan identifying strategies for obtaining the following credits, as applicable:
   2. Credit MR 3: Salvaged and refurbished materials.
   4. Credit MR 5: Regional materials.
   5. Credit MR 7: Certified wood products.

C. LEED Progress Reports: Require Contractor to provide, with each Application for Payment, a progress report comparing construction and purchasing with LEED action plans.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Specify products and procedures necessary to obtain the LEED credits identified in the project LEED checklist, considering the following:
   1. Credit MR 3: Salvaged, refurbished or reused materials.
   2. Credit MR 4: Recycled content of material.
   3. Credit MR 5: Regional materials.
   5. Credit IEQ 4: Low-Emitting Materials

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT
A. Credit MR 2: Develop a construction waste management program sufficient to achieve the level indicated in LEED checklist.

3.2 CONSTRUCTION INDOOR-AIR-QUALITY MANAGEMENT

A. Credit IEQ 3: Require Contractor to comply with requirements during construction and before occupancy to achieve these credits. Additional construction indoor-air-quality procedures are specified in Section 01 35 46 – Indoor Air Quality Procedures.

END OF SECTION 01 81 13
SECTION 02 81 00 - TRANSPORTATION/DISPOSAL OF HAZARDOUS MATERIAL

PART 1 - GENERAL

1.1 SUMMARY

A. This section provides standards for discovery, abatement, disposal, and worker protection for all hazardous materials including asbestos, lead, polychlorinated biphenyls (PCBs), mercury, radioactive materials, and mold.

B. All hazardous materials and waste must be managed and coordinated with Environmental Health and Safety (EHS) through the University Project Manager.

1.2 REFERENCES

A. Occupational Safety and Health Administration, 29 CFR 1926.1101, Asbestos.


C. Environmental Protection Agency, 40 CFR 763.120, Asbestos Worker Protection Rule.


E. Environmental Protection Agency 40 CFR 261.24, Toxicity Characteristic.

F. Environmental Protection Agency, 40 CFR 262, Standards Applicable to Generators of Hazardous Waste.


H. Code of Colorado Regulation Number 8 Control of Hazardous Air Pollutants, Part B Asbestos Control, 5 CCR 1001 – 10 Part B.


J. Air Quality Control Commission (AQCC) Regulations 19 – Lead-Based Paint Abatement.


1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Performance Requirements - Asbestos

1. Presence on Campus:
   a. Asbestos is present in many buildings in and around the campus. Typical forms of asbestos containing materials (ACM) include pipe insulation, ceiling, wall, floor and roof materials.
   b. Investigate every project where work will occur prior to soil disturbing activities to identify asbestos containing materials (ACM). The University Project Manager is responsible for coordinating and ensuring that an inspection or review of previous surveys and any required sampling be performed prior to finalizing the scope or work and associated budget.
c. Include the cost of investigations, sampling, waste transportation, disposal and associated costs in the cost of the project.

2. Excavation Notifications: Required as described below prior to beginning soil disturbing activities.
   a. Localized Limited Quantity Shallow Hand Digging – No notification required.
   b. Small Scale Localized Hand/Equipment Excavation – No notification required.
   c. Moderate Scale Localized Equipment Excavation – Notification to the University.
   d. Large Scale Equipment Excavation – Notification to the University.

3. Discovery of Asbestos:
   a. Notify contractors and the University Project Manager via project documents to stop work when asbestos is encountered or thought to be encountered. It is the responsibility of the University Project Manager to decide what type of action will follow, in consultation with the University’s EHS Department.

4. Asbestos Removal:
   a. Perform any asbestos removal (abatement), repair, encapsulation or spill clean-up in accordance with the above referenced regulatory standards.
   b. Utilize qualified and trained personnel for abatement design and removal in accordance with the above referenced regulatory standards.

5. Asbestos Containing Waste
   a. Follow the University asbestos waste disposal guidelines and Environmental Protection Agency regulations for disposal of asbestos generated at each project.

B. Performance Requirements – Lead

1. Presence on Campus:
   a. Typical forms of lead containing materials (LCM) include paint, lead shielding materials, electronic equipment, and piping (sink traps).
   b. Consult with EHS through the University Project Manager to determine when LCM investigation is required. The University Project Manager is responsible for coordinating and ensuring that an inspection or review of previous surveys and any required sampling be performed prior to finalizing the scope or work and associated budget.
   c. Include the cost of investigations, sampling, waste transportation, disposal and associated costs in the cost of the project.

2. Discovery of Lead:
   a. Suspect LCM at all painted surfaces of older campus buildings, brick, and walls and floors in rooms designated (or previously designated) for radiography.
   b. Notify contractors and the University Project Manager via project documents when lead is encountered or thought to be encountered. It is the responsibility of the University Project Manager to consult with EHS to decide what type of action will follow.

3. Lead Renovation:
   a. Perform any renovation of lead containing materials, repair, encapsulation or clean-up in accordance with the above referenced regulatory standards.
   b. Utilize qualified and trained personnel for renovation in accordance with the above referenced regulatory standards.

4. Handling of Lead Waste:
   a. Coordinate with EHS through the University Project Manager.
   b. Include all costs associated with handling of lead waste in the Project Cost.

1.4 SUBMITTALS

A. Abatement Specifications:

1. Provide a certified asbestos project manager on all asbestos abatement projects in which the amount of friable asbestos material to be abated exceeds 1000 linear feet on pipes or 3000 square feet on other surfaces.

2. The certified asbestos project manager must prepare and approve written abatement specifications.

3. Coordinate with the University EHS Department for additional requirements per project.
B. Asbestos Waste Manifests:
   1. Prepare hazardous waste manifests for all asbestos waste shipments associated with University asbestos related projects. Submit copies and originals of these manifests in sequential (numerical) order to the University.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

PART 4 - ILLUSTRATIONS

   1. Coordinate with the University Project Manager for attachments.
DISTRIBUTION LIST

UCD
Christina Aguilera
Mike Barden
Dan Kerley
Ken Neeper

Colorado Department of Public Health and Environment
Jeff Swanson

Walsh Environmental
Steve Tarasar
Tom Butts
# University of Colorado
# Anschutz Medical Campus
# Asbestos-Contaminated Soil Management
# Standard Operating Procedure Document

## Table of Contents

1. Purpose .......................................................................................................................... 1
2. Scope ............................................................................................................................. 1
3. Primary Contacts, Roles and Responsibilities ............................................................. 1
4. Definitions and Abbreviations ...................................................................................... 1
5. Disclosure due to Potential to Encounter ACS ............................................................. 3
6. Regulatory Summary and Regulatory References ....................................................... 4
7. Classification of Types of Soil Disturbing Activities ..................................................... 7
8. Excavation Notifications ............................................................................................. 8
9. Excavation Planning ..................................................................................................... 9
10. Training Requirements ............................................................................................... 9
11. ACS Characterization Protocols and Trigger Levels .................................................. 12
12. Limited Quantity ACS Management Procedures ....................................................... 14
13. Significant Quantity ACS Management Procedures where only Nonfriable Asbestos Material is Present ................................................................. 14
14. Significant Quantity ACS Management Procedures where Friable Asbestos Material is Present ................................................................. 18
15. Special Considerations ............................................................................................... 24
16. Project Reporting ....................................................................................................... 25
17. SOP Review and Revision ......................................................................................... 26
18. Attachments ............................................................................................................... 26

## Attachments

<table>
<thead>
<tr>
<th>Attachment #1</th>
<th>ACS Classification and AMC Boundary Site Drawing (and Survey Drawings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment #2</td>
<td>Historical Buildings and Steam Tunnels Site Drawing</td>
</tr>
<tr>
<td>Attachment #3</td>
<td>SOP Flow Chart</td>
</tr>
<tr>
<td>Attachment #4</td>
<td>Soil Sampling and Analysis Plan (SAP)</td>
</tr>
<tr>
<td>Attachment #5</td>
<td>Remediation Plan</td>
</tr>
<tr>
<td>Attachment #6</td>
<td>CDPHE Notification Summary and Notification Forms</td>
</tr>
</tbody>
</table>
1 Purpose

This Standard Operating Procedure (SOP) document provides written standard operating procedures that are the minimum requirements for the proper training, handling, packaging, and disposal of asbestos-contaminated soil (ACS) during soil disturbing activities at the Anschutz Medical Campus (AMC) of the University of Colorado Denver (UCD). This SOP document provides specific procedures for the “management” of asbestos contaminated soil to remove only that asbestos contaminated soil, necessary to perform the work. Where “remediation” is intended to remove the full extent and depth of asbestos contaminated soil for a specific area, refer to the attached Soil Sampling and Analysis procedures provided as a supplement to this SOP in Attachment #4 and Remediation procedures provided as a supplement to this SOP in Attachment #5 of this document. The SOP was prepared for CDPHE review and approval to allow AMC to use this SOP for management of the discovered ACS rather than preparing a site specific soil characterization and management plan (SCMP) each time ACS is discovered at ACM. This document is intended for use by those directly involved with soil disturbing activities on the campus, and those who provide management/supervision of these soil disturbing activities.

UCD AMC is part of the University of Colorado and is a 227-acre campus devoted to biomedical education, patient care, and drug development is located in Aurora, Colorado on the site of the former Fitzsimons Army Medical Center. The campus is located on the north side of Colfax Avenue, between Peoria Street and Fitzsimons Parkway.

2 Scope

The procedures provided in this document shall apply to all personnel and all activities involved with the disturbance of soil known to contain asbestos material or soil that may reasonably be considered to contain asbestos material.

3 Primary Contacts, Roles and Responsibilities

<table>
<thead>
<tr>
<th>Organization</th>
<th>Role/Responsibility</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCD – Facilities Management</td>
<td>Project Management</td>
<td>Ken Neeper, Manager Infrastructure Development, Phone: 303.724.0249 Email: <a href="mailto:Ken.Neeper@UCDenver.edu">Ken.Neeper@UCDenver.edu</a></td>
</tr>
<tr>
<td>UCD – Environmental Health and Safety Division</td>
<td>Environmental Compliance – Health and Safety</td>
<td>Christina Aguilera Phone: 303.724.0242 Email: <a href="mailto:Christina.Aguilera@ucdenver.edu">Christina.Aguilera@ucdenver.edu</a></td>
</tr>
<tr>
<td>CDPHE HMWMD</td>
<td>Regulatory Agency</td>
<td>Jeff Swanson – Remediation and Restoration Unit – Federal Facilities Program Phone: 303.692.3416 <a href="mailto:jrswanson@cdphe.state.co.us">jrswanson@cdphe.state.co.us</a></td>
</tr>
<tr>
<td>Non-ACS Excavation Contractor</td>
<td>As needed excavation of non-ACS soil in accordance with this plan</td>
<td>To be determined as needed</td>
</tr>
<tr>
<td>ACS Excavation Contractor</td>
<td>As needed removal of ACS in accordance with this SOP</td>
<td>To be determined as needed</td>
</tr>
<tr>
<td>ACS Consultant</td>
<td>As needed ACS Consulting (soil characterization, remediation oversight, soil spotting, air monitoring)</td>
<td>To be determined as needed</td>
</tr>
</tbody>
</table>

4 Definitions and Abbreviations

4.1 Abbreviations

ACM Asbestos-containing materials
4.2 Definitions

“Air Monitoring Specialist” means a person who performs air monitoring referred to in this guidance and who is certified to perform air monitoring in accordance with Air Regulation No. 8, Part B.

Asbestos Soil Inspector means a person certified in accordance with Air Regulation No. 8, Part B, to perform asbestos inspection and sampling, and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections.

“Asbestos Supervisor” means a person who has been certified as an asbestos Supervisor in accordance with Air Regulation No. 8, Part B.

“Asbestos Project Designer” or “Project Designer” means a person who has been certified as an asbestos Project Designer in accordance with Air Regulation No. 8, Part B.

“Adequately wet” means sufficiently mix or penetrate with liquid to completely prevent the release of particulate material and fibers into the ambient air. If visible emissions are observed coming from asbestos-contaminated soil or asbestos-containing material, then the material has not been adequately wetted. However, the absence of visible emissions is not sufficient evidence of being adequately wet. Guidance on determining when a material is adequately wet can be found in EPA’s Asbestos NESHAP Adequately Wet Guidance, EPA 340/1-90-019 (December 1990).

"Asbestos" means the asbestiform varieties of serpentinite (chrysotile), riebeckite (crocidolite), amosite (cumminstonite-grunerite), anthophyllite, and actinolite-tremolite.

“Asbestos-contaminated soil” means soil containing any amount of asbestos.

"Asbestos waste" means any asbestos-containing material whether it contains friable or nonfriable asbestos, that is not intended for further use. This term includes but is not limited to asbestos mill tailings, asbestos from pollution control devices, and containers that contain asbestos.

"Asbestos-containing material" means any material that contains more than one percent (1%) asbestos by weight, area or volume.

"Consultant" refers to entity contracted to perform training, inspections, and air monitoring related to soil disturbing activities in accordance with the SOP.

"Contractor" refers to entity contracted to perform soil disturbing activities in accordance with the SOP.

“Facility Component” means any component associated with a structure, installation, or building and includes buried utilities, tanks, structures or other installations.

“Friable” means that the material, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure, and includes previously nonfriable material after such previously nonfriable material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure.

“Leak tight” means that solids, liquids, or gases cannot escape or spill out. It also means dust tight.

“Mechanical” means operated or produced by mechanism or machine. This may include, but shall not be limited to, an excavator, backhoe, grader, tiller, auger, or hand shovel.

“Nonfriable” means material which, when dry, may not be crumbled, pulverized, or reduced to powder by hand pressure.
“Remediation” or “Remediate” means a cleanup or removal to prevent or minimize the possible current or future release of hazardous substances to prevent an unacceptable threat to present or future public health, welfare or the environment.

“Site” or “solid waste disposal site” means the location for a facility chosen based upon geologic, hydrogeologic and operational considerations. For the purpose of Section 5.5 of the Solid Waste Regulations “site” means the area or areas where soil-disturbing activities are occurring or will occur.

“Soil-disturbing activities” means excavation, grading, tilling, or any other mechanical activity used to disturb the soil.

"Visible emissions" means any emissions which are visually detectable without the aid of instruments, coming from material containing asbestos, asbestos waste, asbestos-contaminated soil, or from handling and disposal of asbestos waste, material containing asbestos or asbestos-contaminated soil.

"Work Area" means the area where soil disturbing activities are occurring. For asbestos contaminated soil disturbance, Work Area also means the regulated/controlled area boundary.

5 Disclosure due to Potential to Encounter ACS

The Anschutz Medical Campus (AMC) formerly the Fitzsimons Army Medical Center contained numerous buildings, some of which had been demolished and buried by the Army prior to property transfer to UCD. During development of the site by UCD, buried asbestos-containing materials located on building components (primarily direct buried steam lines, etc) and areas of asbestos-contaminated soil (asbestos debris in soil from prior building demolition, etc) have been discovered on the site. Based on excavation activities to date, these occurrences can be characterized as localized. Based on historical findings, the potential to encounter ACS on the AMC campus fall into one of the three following categories:

1. **Known ACS Area** - An area that is classified as having known ACS is one that has confirmed asbestos-containing material in the soil identified either from subsurface intrusive investigation, or from visual observation on the surface, in sidewalls, embankments, etc. This excavation is conducted by properly trained personnel in accordance with the provisions of this SOP.

2. **Moderate to High Potential ACS Area** – An area that is classified as having a moderate potential for encountering ACS is one based on historical review that asbestos material may be encountered in the soil where non-suspect construction debris has been observed historically, including wood, concrete, brick and metal components. An area that is classified as having a high potential for encountering ACS is one based on historical review that suspect asbestos material is likely to be encountered in the soil where suspect asbestos construction debris has been observed historically. Areas of Moderate to High Potential for encountering ACS may necessitate additional characterization using surface and subsurface visual inspection methods. For areas of Moderate to High Potential ACS, soil excavation activities shall be observed by an asbestos building inspector with 6 months asbestos in soil experience (asbestos soil inspector). For areas of Moderate to High Potential ACS “On-the-job” ACS awareness training shall be provided to workers directly involved with soil-disturbing activities.

3. **Low Potential ACS Area** – An area that is classified as having a low potential for encountering ACS is one in which historical review does not identify buildings or structures that previously existed at the site, utility corridors, other waste materials, or other indications that asbestos may exist on the site. A site classified as having a low potential for encountering ACS would not be a “reason to believe that visible asbestos may be encountered.” Sites with a low potential for encountering ACS would not necessitate additional characterization, spotting, “on-the-job” awareness training, or other special provisions. However, if construction debris or potential ACM is encountered during the course of soil disturbance, then the area would become a moderate to high potential ACS area and will be subject to awareness training, soil spotting and other provisions as described in this SOP.

Asbestos debris in soil at AMC can consist of friable asbestos debris (pipe insulation, etc), nonfriable asbestos debris (floor tile and cement asbestos sheet used on roofs, etc), or a combination of both. Asbestos debris may be limited to a few small pieces that are removed under limited quantity discovery” procedures, or may be in a more extensive “debris field” that will be removed under “significant discovery procedures” as described in Sections 11 and 12 of this SOP.
Upon the discovery of any suspected construction debris material, the contractor shall immediately stop excavation activities in that area, and notify the UCD project manager so the condition can be inspected to determine if asbestos contaminated soil is present. These determinations will be made by an asbestos soil inspector which is an EPA accredited and CDPHE certified asbestos building inspector with 6 months soil inspection experience. Where asbestos contaminated soil is identified, this material shall be removed by a qualified contractor with properly trained personnel, in accordance with applicable regulations and procedures described in this SOP.

6 Regulatory Summary and Regulatory References

6.1 CDPHE Hazardous Materials Waste Management Division (HMWMD) – “Asbestos Contaminated Soils” not associated with the “Built Environment”

To address asbestos in soil, the Colorado Department of Public Health and Environment’s Hazardous Materials and Waste Management Division (HMWMD) has established specific management requirements for asbestos-contaminated soil under Section 5.5 of the Regulations Pertaining to Solid Waste Disposal Sites and Facilities (6 CCR 1007-2). Disposal of ACM, and work done in asbestos-contaminated soil (ACS), must comply with this regulation. The requirements of Section 5.5 of the Solid Waste Regulations apply to the owner or operator of any property with asbestos-contaminated soil at which soil-disturbing activities are occurring or planned for any area containing asbestos-contaminated soil. The requirements of Section 5.5 are triggered when the owner or operator has reason to believe or suspect the presence of asbestos-contaminated soil at a site, (through confirmation by analysis of observed material that is suspected of containing asbestos), or has reason to believe or suspects that visible asbestos will be encountered. An owner or operator that has no reason to know of or suspect asbestos-contaminated soil at a site does not have a duty to sample or otherwise investigate for asbestos-contaminated soil prior to commencing excavation, or other soil disturbing activities, at the site. It is important to understand that there is no language in the Solid Waste Regulations that requires an owner or operator to perform soil-disturbing activities, or to remediate asbestos-contaminated soil. The regulations include specific requirements that apply if asbestos-contaminated soil is disturbed or will be disturbed.

To supplement the regulation, CDPHE developed a guidance document intended to provide direction to contractors, consultants and property owners who are involved in soil disturbing activities in areas with known or suspected asbestos-contaminated soil, or where asbestos-contaminated soil is discovered. The guidance is meant to assist in compliance with the Solid Waste Regulations, and where applicable, Air Quality Control Commission Regulation No. 8, Part B (5 CCR 1001-10, Part B - Asbestos).

CDPHE Solid Waste Regulations identify two methods for addressing ACS, Management and Remediation.

1. Management is the removal of only that asbestos-contaminated soil necessary to perform the work, without the intent to remove additional soil outside the scope, even where observed. Management of soil in place is included under this activity. Under management, post removal soil sampling is recommended but not required for soil management actions.

2. Remediation is the planned removal of all asbestos-contaminated soil, removing soil beyond a particular scope of work to remove visible and analytical documented presence of asbestos. Under remediation, clearance soil sampling is required.

Both Management and Remediation approaches require CDPHE approval of a site specific soils work plan or a standard operating procedures (SOP) plan.

Remediation would be the appropriate action where a “No Further Action” letter is sought from CDPHE, or where a consent order has been issued by CDPHE, or when “closure” documentation is desired, as Management is the more accepted cost effective option to address soil contamination where this “No Further Action” is not required.
Remediation of asbestos-contaminated soil is not required under the Solid Waste Regulations, but may be conducted in accordance with Section 5.5.5 of the Regulations. It should also be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations; however, the information that can be gained from sampling may be beneficial for many projects. In addition, when conducting remediation required by CDPHE (consent order, etc), sampling may be necessary to demonstrate that cleanup objectives have been met. Remediation will only be conducted at AMC where it is the intent to remediate and/or receive a no further action letter.

In accordance with Section 5.5.2 of the Solid Waste Regulations, the following projects are exempt from the requirements of Section 5.5 of the Solid Waste Regulations, but may be subject to other sections of the Solid Waste Regulations or other regulatory programs:

1. In situations where the soil contains solely nonfriable material containing asbestos, that has not been rendered friable, the nonfriable material can be removed from the soil and properly disposed in accordance with Section 5.2 of the Solid Waste Regulations. The surrounding soil would not be considered to be asbestos-contaminated soil, and therefore would not be subject to the requirements of Section 5.5 of the Solid Waste Regulations. The determination that a material is nonfriable must be made by an asbestos Building Inspector who has been certified in accordance with AQCC Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections (see Section 8.3 Worker Training).

2. The requirements of Section 5.5 of the Solid Waste Regulations do not apply to asbestos abatement of facility components (including pipes, ducts and boilers) conducted in accordance with AQCC Regulation No. 8, Part B. However, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.

3. The requirements of Section 5.5 of the Solid Waste Regulations do not apply to spill response activities that are subject to the requirements of AQCC Regulation No. 8, Part B. As above, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.

4. Ambient occurrences of asbestos that are not due to site-specific activities. Ambient occurrences of asbestos may include, but are not limited to, naturally occurring asbestos or the distribution of asbestos from normal wear of automotive products.

5. Projects involving excavations with a total volume of less than 1 cubic yard of soil using low-emission excavation methods such as hand held tools or light equipment.

The exemption for asbestos abatement projects conducted under AQCC Regulation No. 8, Part B, includes asbestos debris that may come into contact with soil during demolition of structures with asbestos-containing materials and materials containing trace amounts of asbestos (including trace soil in crawlspaces, loose fill vermiculite, etc) that can legally remain during demolition and be disposed of as normal demolition debris. Any asbestos debris left behind after the completion of a demolition project and associated site cleanup, would be subject to the requirements of Section 5.5 of the Solid Waste Regulations if disturbed in the future.

6.2 EPA, OSHA DOT and CDPHE Air Pollution Control Division (APCD) “Asbestos/Asbestos Contaminated Soils” associated with the “Built Environment”

The Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA) and the Colorado Department of Public Health and Environment (CDPHE) define asbestos-containing material (ACM) as any material containing greater than 1% asbestos as asbestos-containing material. EPA, OSHA and CDPHE define friable materials as those materials that can be crumbled or reduced to powder by hand pressure, whereas nonfriable materials cannot. Friable materials are more likely to be released into the air, especially during renovation and demolition of the building. Under EPA and CDPHE regulations, certain types of nonfriable materials (such as tar impregnated roofing and vinyl asbestos floor tile) may remain during normal demolition (provided these materials remain nonfriable during the demolition process) and also may be disposed of as normal demolition debris. In addition drywall joint compound that contains greater than 1% asbestos may remain in a building for demolition and disposal as normal demolition debris provided the joint compound was not used as a surfacing material and the composite result of the drywall and joint compound reported less than 1% asbestos. Additionally, materials containing trace to 1% are not subject to EPA and CDPHE regulations and may remain in a building during
demolition and may be disposed of as normal demolition debris. Under these provisions, it is common for asbestos to remain in a building for demolition and for subsequent disposal as normal demolition debris.

ACM is subject to the EPA National Emissions Standards for Hazardous Air Pollutants (NESHAPs) Regulations for Asbestos (40 CFR Part 61) which includes specific provisions for renovation and demolition projects pertaining to the “built” environment, and disposal of asbestos-containing waste material. ACM is subject to the EPA Toxic Substances Control Act (TSCA) which includes provisions for training and certification for asbestos remediation and consulting activities. The CDPHE is presently responsible for administering the EPA NESHAP and TSCA program for Colorado.

ACM is subject to OSHA Construction Industry Standard for Asbestos (29 CFR Parts 1910.1101). Materials containing 1% or less asbestos may be subject to OSHA regulations under certain classes of work activity, or if air concentrations are at or above the personal exposure limit (PEL) of 0.1 f/cc or the excursion limit of 1.0 f/cc. The OSHA asbestos standard includes provision for hazard communication, training, exposure assessment, respiratory protection, engineering controls, medical evaluations, and other provisions.

ACM is subject to Department of Transportation (DOT) regulations for packaging, labeling and transportation of asbestos under 49 CFR Part 173.

ACM is subject to applicable requirements of the CDPHE Air Pollution Control Division’s (APCD) Regulation 8. The term Abatement is defined by the CDPHE under the Air Pollution Control Division Regulation 8, and includes the removal of asbestos-containing materials covering facility components, which includes discovery wrapped steam line found below grade, transite® water pipe, or an abandoned buried boiler covered with asbestos. Removal of asbestos in soil associated with facility components would be subject to the requirements under CDPHE Air Pollution Regulation 8, including contractor licensing, worker certifications, permitting, etc.

1. Removal of asbestos-containing material on a facility component, that is located on or in soil that will be disturbed, shall be conducted (as stipulated under Section 5.5 of the Solid Waste Regulations), in accordance with work practices in AQCC Regulation No. 8, Part B, Section III.O, but is not subject to the permit requirements of AQCC Regulation No. 8, Part B, as long as the total quantity of asbestos-containing material is below the following trigger levels:
   a) 260 linear feet on pipes,
   b) 160 square feet on other surfaces, or
   c) The volume equivalent of a 55-gallon drum.

2. Removal of asbestos-containing material on a facility component with asbestos quantities above the trigger levels is subject to the notification, permit, and abatement requirements of AQCC Regulation No. 8, Part B, and is therefore outside the scope of Section 5.5 of the Solid Waste Regulations, as provided in Section 5.5.2(B) of the regulations.

3. Removal of pieces of asbestos-containing material, that are not on a facility component, and are located on or in soil that will be disturbed, shall be conducted under Section 5.5 of the Solid Waste Regulations, in accordance with work practices in AQCC Regulation No. 8 - Part B, Section III.O. The removal activities would not be subject to the permit requirements of AQCC Regulation No. 8, Part B.

Under EPA NESHAPs/CDPHE APCD regulations, the primary consideration under this SOP is adherence to CDPHE APCD Regulation 8 requirements for the discovery of asbestos-containing materials on buried facility components such as piping, boilers, etc and the proper removal in accordance with the EPA NESHAPs and CDPHE APCD regulations. Under CDPHE APCD regulations, secondary consideration under this SOP is the proper removal of all construction debris including nonfriable materials allowed to remain during demolition, asbestos-containing joint compound (where composite result reported less than 1%) and trace-1% asbestos materials. Where demolition debris is allowed to remain after demolition activities have been completed, any presence of asbestos in the soil would then be subject to the CDPHE HMWD ACS regulations. This issue is addressed in more detail in Section 13 (Special Considerations) of this SOP.

All work on asbestos-containing materials (ACM) must comply with the applicable requirements of EPA, OSHA, DOT and CDPHE APCD asbestos regulations.
6.3 References


CDPHE. 2006. *Asbestos-Contaminated Soil Regulations*. Section 5.5 of the Hazardous Materials and Waste Management Division’s Regulations Pertaining to Solid Waste Disposal Sites and Facilities


OSHA. *Construction Industry Standards for Asbestos*. 29 CFR 1926.1101

7 Classification of Types of Soil Disturbing Activities

The following are the classifications of soil disturbing activities under this SOP.

1. **“Localized Limited Quantity Shallow Hand Digging”** - This covers localized limited quantity (less than 1 cubic yard of soil) shallow hand digging from surface to 24 inches in depth, that is typical in the normal day-to-day operations of the campus, including sprinkler repair, planting shrubs and small potted plants, and installing fence posts/signs, etc.

2. **“Small Scale” Localized Hand/Equipment Excavation** - This covers deeper (greater than 24 inches) localized excavation generating greater than 1 cubic yard of soil, and includes hand digging or small/light equipment (backhoe, mini excavator, tree planters, mini-excavators, and hole drilling augers, etc) for minor utility repair, tree planning, etc. With these types of excavations, the work is a very short (day duration), and the soil is typically deposited in the same location from which it is removed, and is not typically subject to relocation.

3. **“Moderate Scale” Localized Equipment Excavation** – This covers larger scale “localized” excavations that involve trenching or pothole excavation typically to install or repair buried utilities. With these types of excavations, the work is a is short to moderate duration (days to weeks), is conducted with a moderate sized “back-hoe” or excavator” and the soil is typically deposited in the same location from which it is removed, and is not typically subject to relocation. An example of this would be utility corridor trenching.

4. **“Large Scale” Equipment Excavation** – This covers largest scale excavations that involve mass excavation of a site, usually for building construction or other site development purposes. With these types of excavations, the work is a moderate to long duration (weeks to months), is conducted with large excavators, scrapers, front end loaders, etc, and the soil is typically subject to relocation on and off-site, with potential for additional soil import, depending on final grade requirements. An example of this would be “mass excavation” performed for construction of a new building.
8 Excavation Notifications

The following table summarized the types of notifications required prior to conducting soil disturbing activities.

<table>
<thead>
<tr>
<th>Low Potential ACS condition</th>
<th>Moderate to High Potential ACS condition</th>
<th>Known ACS condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Localized Limited Quantity</strong> (less than 3 cubic yards) Shallow Hand Digging (less than 24 inches in depth for sprinkler repair, shrub/planting small potted plants, installing fence posts/signs etc.)</td>
<td>No notification required</td>
<td>No notification required</td>
</tr>
<tr>
<td><strong>Localized Small Scale</strong> Hand/Equipment Excavation more than 3 cubic yards and greater than 24 inches in depth (minor utility repair, tree planning, etc)</td>
<td>No notification required</td>
<td>Notification to UCD prior to start</td>
</tr>
<tr>
<td><strong>Moderate Scale</strong> Localized Equipment Excavation (utility trenching)</td>
<td>Notification to UCD prior to start</td>
<td>Notification to UCD prior to start</td>
</tr>
<tr>
<td><strong>Large Scale Equipment Excavation</strong> (mass excavation)</td>
<td>Notification to UCD prior to start</td>
<td>Notification to UCD prior to start</td>
</tr>
</tbody>
</table>

CDPHE will be notified within 24 hours of an unexpected ACS and/or ACM discovery. CDPHE will be notified at least 10-days prior to any planned soil-disturbing activity in areas of known ACS and/or ACM. The HMWMD can be notified by using the Notification Form attached to this plan, and emailed to CDPHE contact identified in Section 3 of this SOP. If ACS is encountered and an area reclassified as “known ACS condition” that CDPHE will be notified prior to start or re-start of work.

Additional notification shall be provided to UCD if construction debris is encountered in areas determined to be low potential ACS condition. Notification to UCD includes notification to UCD Facilities Planning Department contact and UCD Environmental Health and Safety Division contacts as provided in Section 3 of this SOP. The Contractor shall notify and receive approval from the UCD project manager prior to any soil being exported or imported to the project. Contractor shall coordinate any inspections, spotting, or testing requested by the UCD project manager for any exported or imported soils to the project. For emergency repair projects to utilities, etc, notification will be provided to CDPHE by the next business day.
9 Excavation Planning

Prior to performing any soil disturbance activities, those persons performing the soil disturbing activity shall check the AMC ACS Asbestos Contaminated Soils Classification Site Drawing (Attachment #1) to determine the classified ACS condition for the area where soil disturbing activities will occur. Comply with notification, training and work procedures provisions of this document based on the classified condition for the area where excavation will occur which will be classified into one of the following three categories:

- **Low Potential ACS Condition (areas shaded green)**
- **Moderate to High Potential ACS Condition (areas shaded yellow)**
- **Known ACS Condition (shaded coded red)**

The following soil spotting activities will be utilized during all excavation activities for moderate to large scale excavation activities when moderate to high potential ACS conditions exist:

1. All surface work areas will be pre-inspected by the asbestos soil inspector prior to commencement of soil disturbance activities.
2. Excavation Area: conduct a subsurface visual inspection for asbestos material during excavation. The asbestos soil inspector will inspect all areas of the excavation as removal of soil proceeds, and will inspect the bottom of the excavation for visible ACM.
3. Stockpile and Backfill Areas: closely inspect stockpiled area as soil is dumped/piled.

Where ACS is identified and impacted by planned excavation, the characterization, removal and disposal of contaminated soil shall be conducted in accordance with the provisions of this SOP. Once the asbestos soil inspector has delineated the ACS boundaries (depth and extent through visual inspection characterization protocols as provided in Section 11 of this SOP), the Contractor may continue excavation in other non-ACS areas with continued spotting by an asbestos soil inspector.

For localized limited quantity (less than 1 cubic yard) shallow (less than 24 inches) hand digging for normal day-to-day operations, including sprinkler maintenance, installation of signs/posts, planting of small plants and shrubs, etc, these activities are exempt from this SOP since these activities typically occur in newly constructed areas with shallow digging occurring in the top fill layer placed during new construction, which has a low potential to contain asbestos debris, and less than 1 cubic yard by hand-digging is exempted under CDPHE HMWMD regulations. Notification shall be provided to UCD if construction debris is encountered under these exempted activities.

For additional planning purposes and as a reference, an historical site map is provided in Attachment #2 that shows the building and steam tunnel locations for the former Fitzsimons Army Medical Center. Attachment #3 contains a flow chart that summarizes the key components of this SOP document.

10 Training Requirements

10.1 SOP circulation

The following entities/persons involved with soil disturbing activities shall be provided a copy of this SOP prior to performing work.

1. Those performing soil disturbing activities in areas with moderate to high potential to encounter ACS
2. Those providing awareness soil training
3. Those providing soil inspection or soil spotting activities during normal excavation activities.
4. Those performing soil disturbing activities in a known ACS condition area
5. Those providing air monitoring and inspection associated with soil disturbing activities in a known ACS condition area.

10.2 Awareness Training

For areas with moderate to high potential to encounter ACS, all those persons involved with the excavation regardless of size shall be provided on the job hazard communication awareness (awareness) training for those individuals associated with the soil disturbing activities as follows:

“On-the-job” asbestos soils awareness training as defined in Section 5.5.6 of the Solid Waste Regulations will be provided to workers directly involved in soil-disturbing activities on sites where there is known ACS or a “reason to believe” ACS may be encountered. The training will address such topics as history and background of asbestos, identifying types of asbestos, health effects, engineering controls, and actions to take when suspect asbestos materials are encountered. The training will be conducted with oversight and curriculum development by an asbestos building inspector, asbestos supervisor or project designer.

The awareness training must provide information necessary for the individuals to perform their duties in a way that ensures compliance with the requirements of Section 5.5 of the Solid Waste Regulations. The training must be conducted by an Asbestos Supervisor, Building Inspector or Project Designer, certified in accordance with AQCC Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil management.

10.3 ACS Soil Disturbance Training

For moderate to large scale excavation activities in areas with known ACS, provide on the job hazard communication awareness training for those individuals associated with the soil disturbing activities. In addition personnel overseeing, directing, inspecting and/or handling asbestos or asbestos-contaminated soil during soil excavation activities shall have the following minimum training and certifications:

1. At least one (1) trained supervisor (competent person) shall be on site during excavation activities (current EPA Asbestos Supervisor Certification)
2. CDPHE HMWMD training required for persons performing asbestos-contaminated soil disturbing activities including on the job asbestos contaminated soil awareness training and training in accordance with OSHA standard 1926.1101 (k) (9) (vii) for those performing soil disturbing activities in an area with asbestos waste or asbestos contaminated soil (EPA Asbestos Supervisor/Worker training is recommended).
3. A current annual physical with medical release / respirator usage form and respirator fit test.

This training requirement applies to equipment operators but is not required for drivers of trucks carrying contaminated material for disposal to approved landfills. Drivers are only required to complete the awareness training.

For Small Scale excavation activities with known ACS, provide awareness training for those individuals associated with the soil disturbing activities. In addition personnel overseeing, directing, inspecting and/or handling asbestos or asbestos-contaminated soil during small scale soil excavation activities shall have the following minimum training and certifications:

1. At least one (1) trained supervisor (competent person) shall be on site during excavation activities.
2. CDPHE HMWMD training required for persons performing asbestos-contaminated soil disturbing activities including on the job asbestos contaminated soil awareness training and training in accordance with OSHA standard 1926.1101 (k) (9) (vii) for those performing soil disturbing activities in an area with asbestos waste or asbestos contaminated soil (Training Equivalent with OSHA Class III training for “small scale short duration” activities that will disturb asbestos recommended).
3. A current annual physical with medical release / respirator usage form and respirator fit test.

10.4 ACS Inspection and Air Monitoring Training

Individuals performing soil inspection and identification of asbestos in soil must have a current asbestos Building Inspector certification in accordance with AQCC Regulation No. 8, Part B, and must have a minimum of six (6) months experience conducting asbestos-contaminated soil inspections. Individuals with this level of training and experience are referred to in this SOP as “asbestos soil inspectors”.

Individuals preparing and signing Soil Characterization and Management Plans must have a current Asbestos Project Designer certification in accordance with AQCC Regulation No. 8, Part B.

Individuals performing asbestos air monitoring associated with asbestos-contaminated soil disturbing activities must have a current Air Monitoring Specialist certification in accordance with AQCC Regulation No. 8, Part B.

10.5 Additional Considerations

In addition, individuals with the potential for exposure to asbestos fibers should be trained in the proper usage of personal protective equipment and have a current annual physical with a medical release/respirator usage form in accordance with the employer’s medical surveillance program. Personal exposure air monitoring should be conducted in accordance with the employer’s exposure assessment program.
11 ACS Characterization Protocols and Trigger Levels

The following summarizes the potential conditions that may be encountered during soil disturbing activities at the AMC:

1. Localized areas of friable and/or nonfriable asbestos debris in soil that constitute “significant quantity” as provided under the “trigger level” of this plan. Triggering “major” response procedures as provided in this plan.
2. Localized areas of friable and/or nonfriable debris in soil that constitute “limited quantity” as provided under the “trigger level” portion of this plan, triggering “minor” spill response during planned excavation spotting activities.
3. Localized areas with construction debris with no asbestos debris, such as brick, metal, and PVC pipe, and non-asbestos suspect debris (confirmed by bulk sampling).
4. Localized areas where no visible construction debris, or visible suspect asbestos containing materials are present.

To provide a basis for appropriate level of assessment (limited vs. significant) and management for discovered asbestos debris, the following summarizes specific trigger levels to be used under this SOP. These trigger levels are “limited quantity discovery” and “significant quantity discovery” of visible friable and/or nonfriable asbestos debris and have corresponding assessment and response actions based on the limited or significant finding:

11.1 Limited Quantity Material Discovery Assessment and Management Protocol

**Entry into Limited Quantity Assessment and Management Protocols:** Where up to 3 pieces (with multiple pieces of asbestos within a few inches of each other to be treated as one piece of asbestos) of friable and/or nonfriable asbestos debris are identified within a 10-foot radius, record the locations with a GPS unit, photograph and log pertinent information such as location, description of material, type of debris, etc.

**Exit from Limited Quantity Assessment and Management Protocols:** Carefully wet and remove the visible debris and 3 cubic feet of soils surrounding each debris piece. All debris will be adequately wetted, and removed by appropriately trained and protected personnel. All debris and associated soil will be placed into appropriately labeled disposal bags, for proper disposal based on the material friability.

11.2 Significant Quantity Material Discovery Assessment and Management Protocol

**Entry into Significant Quantity Assessment and Management Protocols:** Where greater than 3 pieces (with multiple pieces of asbestos within a few inches of each other to be treated as one piece of asbestos) of friable and/or nonfriable asbestos debris are identified within a 10-foot radius, this will constitute a debris field. The asbestos soil inspector will conduct surface and subsurface visual assessment with the assistance of excavation equipment to determine the extent and depth of the asbestos debris field. All
asbestos debris field corner points will be documented with a GPS unit, on a drawing and by photograph. Photograph and log pertinent information such as type of debris, quantity, etc.

Exit from Significant Quantity Assessment and Management Protocols: Removal of debris field based on a visual determination to the extent of excavation, or removal of extent of find (EOF) plus 1 foot of soil, and removal of depth of find (DOF) plus 1 foot of soil for subsurface contamination, and removal of extent of find (EOF) plus 1 foot of soil where only surface contamination is identified. Where visible friable and/or nonfriable asbestos debris is still observed at the extent of planned excavation, the area will be over excavated by 1 foot, and then covered with a geotechnical membrane and labeled/demarcated as asbestos-contaminated soil, and covered with 1 foot of clean fill. The boundary will be recorded with a GPS unit, on a drawing, and by photograph.

11.3 Visual Characterization for Significant Discovery
Site characterization (surface and subsurface visual assessment) will be conducted by using visual inspection to identify depth and extent of visible significant debris using potholing and trenching techniques for asbestos debris. Soil sampling and analysis is not part of the characterization process under this SOP, and any collection and analysis of soil samples for asbestos content requires written authorization from UCD.

11.4 Surface Investigation
Surface investigation for areas identified as having potential asbestos-containing debris will be conducted for suspect asbestos debris. Surface investigation will include sampling suspect asbestos-containing material, or will assume material is asbestos-containing. Marker paint and flags will be used to demarcate locations of any suspect debris. Locations will be identified with a GPS device. The surface investigation will include photographing and logging pertinent information such as location, type of debris, quantity, etc.

11.5 Investigation Personal Protective Equipment
At a minimum, appropriate PPE must be worn when doing asbestos inspections or otherwise accessing an area suspected or known to contain asbestos. At a minimum, asbestos soil inspectors performing the inspection and/or personnel performing the pickup of non-friable asbestos must wear disposable booties and disposable rubber gloves, which should then be discarded as asbestos waste prior to exiting the site. At a minimum, asbestos soil inspectors performing the inspection and/or personnel performing the pickup of friable asbestos must wear a half-face air-purifying respirator with HEPA cartridge filtration, disposable protective suit, disposable booties and disposable rubber gloves. Disposable protective equipment should then be discarded as asbestos waste prior to exiting the site. Additional protective equipment shall be used as appropriate.

11.6 Demarcation of Discovery Locations and ACS Boundaries
Locating debris and other site conditions by GPS where specified in this SOP is considered the primary method for documenting these locations, but distance measurement (XYZ coordinate) descriptions may be used where a site grid is utilized or where locations are adjacent to structures or features. Grid/Structure reference points shall be documented with GPS in the event grid markers or structures are removed.
12 Limited Quantity ACS Management Procedures

Where the asbestos soil inspector visually observes up to three pieces of friable and/or nonfriable asbestos debris within a ten (10) foot radius, follow the procedures listed below.

For nonfriable asbestos material, adequately wet, using hand-removal methods only, gather and place the material and approximately 12 inches of surrounding soil in 6-mil poly bags. For friable asbestos material, adequately wet, using hand-removal methods only, gather and place material and 3 cubic feet of surrounding soil in 6-mil poly bags (double bags). Continue work with extra attention to possible additional asbestos in that vicinity. Stage waste bags in a lined drum or roll-off container. Dispose of waste as asbestos contaminated waste in accordance with CDPHE regulations and this SCMP.

All personnel involved in the removal of Limited Quantity asbestos debris will wear at a minimum a half-face air purifying respirator with HEPA filtration, and disposable protective suit, disposable overbooties and disposable gloves. Decontamination of all tools and equipment involved in the removal of asbestos debris is required prior to leaving the work area. Disposable suits, overbooties and gloves shall be disposed of as asbestos waste.

13 Significant Quantity ACS Management Procedures where only Nonfriable Asbestos Material is Present

Where the asbestos soil inspector visually observes more than three pieces nonfriable asbestos debris within a ten (10) foot radius, follow the procedures listed below.

13.1 Soil Wetting and Stabilization

The Work Area will be adequately wetted to prevent any fugitive dust emissions that may be generated during initial setup and mobilization into the area. The Contractor shall use water hoses from a tank truck or directly from a fire hydrant or other water source. Water will be applied at low pressure so as to not generate dust or splattering. During all soil disturbing activities, wetting of soil will be sufficient to ensure soils are adequately wet (no visibly dry soil and no visible emissions) throughout the soil disturbing activities.

13.2 Dust and Emissions Control

General dust control will be achieved by use of water trucks that will regularly spread water on all access roads throughout the project site to ensure no visible dust generation by vehicle traffic during soil disturbance activities. Whenever contaminated soil and debris are being impacted, the Contractor will ensure that no emissions are generated. UCD’s representative will be on site to monitor the moisture of the soil being skimmed during removal and will ensure that it is adequately wet (and to observe for any visible emissions). An asbestos soil inspector will conduct these visual inspections.

If emissions are observed during the removal process, activities will immediately cease and work practices will be reviewed and modified by the Contractor. The Consultant will log all instances where visible dust emissions occurred and immediately notify UCD and CDPHE by phone and in writing, of all occurrences, and will obtain any direction from UCD and CDPHE.

13.3 PPE

During the actual soil disturbance activity, all persons within the designated work area shall utilize appropriate personal protective equipment, including appropriate respiratory protection with a minimum half face respirator with HEPA filtration required anytime active soil disturbance is occurring, protective full body tyvek© suit with attached
hood and booties, gloves, rubber boots, and other protective wear as appropriate based on conditions (cold stress, heat stress, insects, etc)

13.4 Removal/Excavation

The Contractor will remove adequately wet soil in lifts with the lift thickness is determined by the depth of the adequately wet soil. The application of amended water to work area will be completed in accordance with all applicable regulations, variances, the work plan, and the on-site observations by the Consultant. Polyethylene sheeting will be placed over uncontaminated soils in the swing radius of the excavator or along the transport route of loading equipment to prevent cross-contamination. Care will be taken to avoid contamination of the excavating equipment. This will be accomplished by driving and keeping excavating equipment on non-contaminated soil.

Equipment that comes in contact with contaminated soil, or that was within the designated work area will be decontaminated. Conduct work with appropriate phasing/sequencing that will minimize cross-contamination potential.

13.5 Wind and Work Stoppage Conditions

Soil disturbance operations will not be conducted if winds produce visible emissions of dust or create dust when moving equipment or soil.

13.6 Environmental Monitoring

During the execution of the soil removal, the AMS will collect air samples to assist in determining the adequacy of the engineering and environmental controls employed at the site. Air monitoring will be conducted during ACS significant discovery soil removal activities where only nonfriable material is visible. All air samples will be collected by a CDPHE certified Air Monitoring Specialist (AMS).
The air monitoring is described below.

1. **Sampling Media:** Air samples will be collected by drawing air through a 25-millimeter mixed cellulose ester filter, 0.8-micron pore size, with an open-faced, long cowl using low-flow personal sampling pumps at approximately 2 liters per minute (or flow rate to provide a sufficient LOQ/LOD). Each low-volume pump will be fitted with a computer microchip, which electronically regulates airflow and allows a fixed flow rate of air to pass over the face of the filter. The flow rate and the volume of air passed through the filter will be determined based on the National Institute for Occupational Safety and Health (NIOSH) 7400 analytical method. Each pump will be calibrated before and after the collection of each sample using a primary standard.

2. **Sample Analysis:** Sample analyses will be performed by a microscopist using a phase contrast microscope (PCM) according to the NIOSH 7400 Method. The microscopist will be a CDPHE certified Air Monitoring Specialist (AMS) and a participant in the NIOSH Proficiency Analytical Testing Program and have been deemed proficient. Analyses of transmission electron microscopy (TEM) air samples will be submitted to a National Institute for Standards and Technology National Voluntary Laboratory Accreditation Program accredited laboratory using TEM according to Asbestos Hazard Emergency Response Act protocol.

3. **The daily air monitoring sampling scheme will be as follows:**
   - Air samples will be strategically placed as close to work area without impeding equipment and worker activity, and will be collected continuously during excavation and loading operations and submitted the same day for PCM analysis. **A total of 5 samples will be collected per shift per work area.**
   - Of the 5 samples collected, three (3) perimeter samples will be placed to triangulate the work area, moving as necessary to follow the active “area-of-disturbance”, but remaining fixed in relation to each other. One (1) additional perimeter “floating sample” will be placed downwind from work activities, where potential fiber emissions are most likely to be detected. All perimeter samples shall be collected as close to the “point of disturbance” as possible, without subjecting the air monitoring equipment to damage from the operations. One (1) additional sample, to be considered the potential worst-case scenario “area equivalent” sample, will be collected on personnel closest to disturbance operations, such as the person operating the water hose.
   - The results from these samples for comparison to 0.01 f/cc (and presence of asbestos for when analyzed by TEM) and should not be construed as “OSHA exposure assessment air samples”.
   - **Performance Based Air Sampling:** Five (5) samples, including personnel and perimeter samples, will be submitted for PCM analysis. If analysis yields results with detectable fiber levels (based on fiber count) then TEM analysis will be conducted on the two (2) highest PCM samples for the first 3 days of each nonfriable excavation event. If no asbestos fibers are detected after the first 3 days of each event, then TEM analysis of the two (2) highest PCM samples will be reduced, to be conducted randomly twice per week. The AMS will determine on which two days **TEM analysis** will be conducted. TEM analysis will continue to be performed on any sample with PCM results exceeding 0.01 fibers/cc.

4. **PCM verbal results will be made available by the start of the next business day or as soon as practical after the start of the next business day.** TEM verbal results will be made available within 24-hours of receipt of samples by the laboratory, and written results will be made available within 24 hours from the time the verbal result is received. UCD and CDPHE will be immediately notified if any sample results show any concentration of airborne fibers. If any asbestos fibers are detected by TEM, all investigative activities will be stopped and engineering controls will be evaluated by Contractor and Consultant, and will be discussed with UCD and CDPHE to determine if changes in engineering controls or additional PPE are required.

5. **As an alternative to Environmental Air Monitoring for significant quantity nonfriable excavation, where soil sampling is performed in areas containing only visible nonfriable asbestos debris (per a soil sampling plan as agreed upon by UCD and CDPHE), and where soil sampling data demonstrates that no asbestos is present in the soil, and excavation work practices will not render the nonfriable material friable, environmental air monitoring may be reduced to PCM on workers only with the written approval of UCD and CDPHE.**

### 13.7 Personal Air Monitoring

Air sampling of personnel is an employer based responsibility, and as such shall be the responsibility of each employer associated with soil disturbing activities. The “area equivalent” samples collected on personnel are
interpreted as “worst case area” samples and are not intended to provide OSHA exposure information, but can be used by employers for general informational purposes.

13.8 Truck/Container Staging/Lining and Waste Loading

All truck drivers will be instructed to close all windows and shut-off air delivery systems (fans on air-conditioning and heating systems) when entering the loading area. All travel and positioning of waste transport Truck/Trailers on the site should be visually verified clean soil to minimize the need for decontamination procedures. At the loading location, install a ten-mil polyethylene sheeting or thicker “lay-down pad” that will be placed on the ground under dumpsters/trucks to catch any spilled material. Spilled material will be cleaned up immediately and not allowed to dry out or accumulate. Additional poly shall be draped over trailer tires/fenders to minimize the need for decontamination after loading. After the load has been secured, and the load cover tarp is installed, the poly sheeting lay down loading pad will be properly decontaminated using wet wipe and or HEPA vacuuming methods. The loaded transportation truck may then proceed down the designated exit route.

13.9 Waste Transportation and Disposal

Containers of nonfriable asbestos waste, asbestos-contaminated soil with visible nonfriable asbestos, or ACS with no visible asbestos will be labeled, in accordance with the requirements of Section 5.2 of the Solid Waste Regulations. In accordance with the disposal requirements for nonfriable asbestos waste at least one 6-mil polyethylene liner/sheeting will be in trucks used for transport of soil that contains visible nonfriable asbestos. Polyethylene liners/sheeting should be designed and sized for the container to be used and should be folded over sides of trailers or containers to protect against contamination during loading and to facilitate decontamination. After loading, the liners/sheeting will be sealed and mechanically fastened in a manner that ensures that it remains intact and leak-tight during transportation and disposal operations. Containers of nonfriable asbestos waste, asbestos-contaminated soil with visible nonfriable asbestos, and asbestos-contaminated soil with no visible asbestos, shall be labeled noting “asbestos, danger” and the generator, and placed on top of sealed liner.

In addition, Department of Transportation (DOT) asbestos placards shall be placed on all four vertical sides of the container or vehicle being used for transport of ACS. The Contractor should direct the schedule of transportation of asbestos-contaminated soil. When loaded, each truck should be assigned a manifest to serve as the shipping document for that particular load.

Asbestos-contaminated soil shall be transported and disposed in a leak tight container in accordance with the CDPHE disposal requirements. Documentation stating that the soil originating from the site will not be used as daily cover or sold as clean fill shall accompany each load of asbestos-contaminated soil removed from the site.

Disposal of asbestos-contaminated soil will be conducted in accordance with the following requirements, in accordance with Section 5.5.7 of the Solid Waste Regulations:

1. Asbestos-contaminated soil containing only visible nonfriable asbestos, that has not been rendered friable, will be disposed of as nonfriable asbestos in accordance with Section 5.2 of the Solid Waste Regulations.
2. Asbestos-contaminated soils containing no visible asbestos will be disposed in a manner similar to nonfriable asbestos waste, as described in Section 5.2 of the Solid Waste Regulations.

13.10 Personnel Decontamination

A fully functioning 3-chamber decontamination trailer (or equivalent) will be placed outside the work zone to function as a remote shower location, with a clean room and an equipment room. All workers involved in removal/packaging ACS will be double suited while in the work area and will shed one suit prior to leaving the work area and immediately proceed to the decontamination facility. All workers will decontaminate per OSHA regulations and CDPHE Regulation No. 8. Decontamination water will be filtered using a 5 micron filter, or in accordance with local requirements if more stringent, prior to disposal to the sanitary sewer.
13.11 Equipment Decontamination

All equipment and tools that come into contact with, or are used for removal of ACS will be decontaminated (free of all visible dust and debris) using wet cleaning (fire hose for trackhoe equipment, wet rags for hand tools, etc) and HEPA vacuuming methods (interior of equipment cab, etc), prior to leaving the work zone. Equipment decontamination will be conducted within a decontamination station constructed adjacent to the work zone. The decontamination station will be constructed of 10-mil polyethylene sheeting (and other materials as necessary, such as EPDM rubber roofing, etc) in such a way as to capture all contaminated material and wastewater from the decontamination process. All waste water from the decontamination station will be filtered to a minimum of 5-microns (or in accordance with local requirements if more stringent, prior to discharge to a sanitary sewer), or may be used for wetting ACS.

13.12 Final Inspection Procedures

As the project progresses, visual inspection will be performed to ensure that all observable asbestos-containing materials have been removed from the soil surface. During removal of soil, the soil will be removed in a manner that will provide a flat, even surface (with no spoil piles) for visual inspection. The inspections will be performed for the surface area removed that day, as a preliminary inspection. Due to the wet nature of the removal and the soil, adequate drying time is required before a final visual inspection can be conducted.

The removal of soil in the debris field area will be considered complete when the visible asbestos-containing material has been removed and an asbestos soil inspector makes a final decision that all contaminated soil in the debris field has been removed to depth and extent of excavation (where remaining visible material will be covered with a membrane and labeled), or depth of find plus 1 foot of soil (DOF+1) and extent of find plus 1 foot of soil (EOF+1).

13.13 Managing ACS left in place

Where visible asbestos containing material is observed at the depth and extent of excavation, 1 additional foot of soil shall be removed, the area shall be covered with a geotech membrane, labeled as asbestos contaminated soil, and then the membrane shall be covered with 1 foot of clean fill to bring back to desired grade/level. Prior to covering with clean fill, photographs will be collected from each compass point of the boundary, and the corner points of the boundary shall be obtained using measurements for a control point or with a GPS device.

14 Significant Quantity ACS Management Procedures where Friable Asbestos Material is Present

Where the asbestos soil inspector visually observes more than three pieces friable asbestos debris within a ten (10) foot radius, follow the procedures listed below.

14.1 Site Control, Demarcation, Fencing and Wind Screening

The Work Area will be demarcated on all four sides using a movable/portable wind barrier to prevent wind dispersal of soil during excavation activities. Moveable/portable wind barriers will be placed on all four sides and immediately adjacent to the point of excavation, and will be of adequate height and configuration (size) to minimize wind soil dispersal at the point of excavation. For smaller areas or highly mobile removal activities, moveable “directional” mobile wind fencing may be used, but must be positioned upwind and adjacent to soil removal activities at all times. Where only directional wind fencing is used, asbestos barrier tape shall be installed to identify the remaining boundary of the Work Area (where wind fence is not positioned).
14.2 Protection of Adjacent Structures

When the abatement area is close to occupied structures, external critical barriers may need to be constructed. All openings in the structure, including windows, doorways, vents or other openings will be sealed with 6-mil poly.

14.3 Soil Wetting and Stabilization

The Work Area will be adequately wetted to prevent any fugitive dust emissions that may be generated during initial setup and mobilization into the area. The Contractor shall use water hoses from a tank truck or directly from a fire hydrant or other water source. Water will be applied at low pressure so as to not generate dust or splattering. During all soil disturbing activities, wetting of soil will be sufficient to ensure soils are adequately wet (no visibly dry soil and no visible emissions) throughout the soil disturbing activities.

14.4 Dust and Emissions Control

General dust control will be achieved by use of water trucks that will regularly spread water on all access roads throughout the project site to ensure no visible dust generation by vehicle traffic during soil disturbance activities.

Amended water and or stabilization agents will be applied for dust control within all disturbed ACS areas. The Contractor will maintain the dust control process throughout the course of the project during soil disturbing activities. Removal of soils and debris will be done with heavy equipment which has been adapted to have a water misting system installed on the equipment to minimize dust emissions at the point of removal. Water will be applied in a manner that does not cause run-off or splattering. In addition, a water misting system will be constructed to wet the material at the point of loading into the dumpster prior to final packaging.

Whenever contaminated soil and debris are being impacted, the Contractor will ensure that no emissions are generated. UCD’s representative will be on site to monitor the moisture of the soil being skimmed during removal and will ensure that it is adequately wet (and to observe for any visible emissions). An asbestos soil inspector will conduct these visual inspections.

Site management and inspectors will monitor the quantity of surface area disturbed at any given time; also the amount of surface not stabilized will be kept to the minimum quantity necessary for meaningful work to occur. If site conditions change so that dust suppression becomes questionable on the amount of disturbed area, a portion of that area will be stabilized and work will proceed on a reduced area.

If emissions are observed during the removal process, activities will immediately cease and work practices will be reviewed and modified by the Contractor. The Consultant will log all instances where visible dust emissions occurred and immediately notify UCD and CDPHE by phone and in writing, of all occurrences, and will obtain any direction from UCD and CDPHE.

14.5 PPE

During the actual soil disturbance activity, all persons within the designated work area shall utilize appropriate personal protective equipment, including appropriate respiratory protection with a minimum half face respirator with HEPA filtration required anytime active soil disturbance is occurring, protective full body tyvek suit with attached hood and booties, gloves, rubber boots, and other protective wear as appropriate based on conditions (cold stress, heat stress, insects, etc).

14.6 Removal/Excavation

Utilizing an excavator, mini excavator or backhoe with a bucket mounted spray bar system; the soil excavation will proceed within the designated work area. The spray bar system will consist of nozzles inside the back top edge of the bucket and two outside the bucket with nozzles spray pattern overlapping that will provide adequate wetting to
eliminate fugitive dust, but avoid splatter or drift from spraying. Additional hand wetting will be used to eliminate fugitive emissions, but avoid splatter or drift from spraying.

The Contractor will remove adequately wet soil in lifts with the lift thickness is determined by the depth of the adequately wet soil. The application of amended water to work area will be completed in accordance with all applicable regulations, variances, the work plan, and the on-site observations by the Consultant. Polyethylene sheeting will be placed over uncontaminated soils in the swing radius of the excavator or along the transport route of loading equipment to prevent cross-contamination. Care will be taken to avoid contamination of the excavating equipment. This will be accomplished by driving and keeping excavating equipment on non-contaminated soil.

Equipment that comes in contact with contaminated soil, or that was within the designated work area will be decontaminated. Conduct work with appropriate phasing/sequencing that will minimize cross-contamination potential.

14.7 Wind and Work Stoppage Conditions

Soil disturbance operations will not be conducted if winds produce visible emissions of dust or create dust when moving equipment or soil. All wind speed measurements will be taken at locations in close proximity to, and representative of, the work area in which the soil is being handled.

**Shutdown conditions:** Soil removal/disturbance operations will immediately and temporarily cease when one or more of the following 4 conditions have been met:

1. Any wind gust reaching or exceeding 20 mph as determined by hand-held instruments;
2. Sustained wind speeds reaching or exceeding 12 mph averaged over a period of 10 minutes;
3. Winds are producing visible emissions or creating movement of dust or debris in or near the removal/disturbance area, or
4. Winds are impacting on the ability of engineering controls to work as designed.

During wind-related work shutdowns, other work activities not involving soil removal or disturbance (e.g., lining dumpsters) may continue.

**Resume Conditions:** Soil disturbance activities may resume after all of the following 4 conditions have been met:

1. All wind gust readings for a period of 20 minutes drop below 20 mph as determined by hand-held instruments;
2. Sustained wind speeds are below 12 mph averaged over a period of 20 minutes;
3. Winds are no longer producing visible emissions or creating movement of dust in or around the removal/disturbance area, and
4. Winds are not impacting on the ability of engineering controls to work as designed.

14.8 Environmental Monitoring

During the execution of the soil removal, the AMS will collect air samples to assist in determining the adequacy of the engineering and environmental controls employed at the site. Air monitoring will be conducted during ACS significant discovery soil removal activities where visible friable asbestos material is present. All air samples will be collected by a CDPHE certified Air Monitoring Specialist (AMS). The air monitoring is described below.

**Sampling Media:** Air samples will be collected by drawing air through a 25-millimeter mixed cellulose ester filter, 0.8-micron pore size, with an open-faced, long cowl using low-flow personal sampling pumps at approximately 2 liters per minute (or flow rate to provide a sufficient LOQ/LOD). Each low-volume pump will be fitted with a computer microchip, which electronically regulates airflow and allows a fixed flow rate of air to pass over the face of the filter. The flow rate and the volume of air passed through the
filter will be determined based on the National Institute for Occupational Safety and Health (NIOSH) 7400 analytical method. Each pump will be calibrated before and after the collection of each sample using a primary standard.

2. Sample Analysis: Sample analyses will be performed by a microscopist using a phase contrast microscope (PCM) according to the NIOSH 7400 Method. The microscopist will be a CDPHE certified Air Monitoring Specialist (AMS) and a participant in the NIOSH Proficiency Analytical Testing Program and have been deemed proficient. Analyses of transmission electron microscopy (TEM) air samples will be submitted to a National Institute for Standards and Technology National Voluntary Laboratory Accreditation Program accredited laboratory using TEM according to Asbestos Hazard Emergency Response Act protocol.

3. The daily air monitoring sampling scheme will be as follows:
   a. Air samples will be strategically placed as close to work area without impeding equipment and worker activity, and will be collected continuously during excavation and loading operations and submitted the same day for PCM analysis. **A total of 8 samples will be collected per shift per work area.**
   b. Of the 8 samples collected, four (4) samples will be arranged at the 4 points of the compass surrounding the work area with two (2) additional samples deemed as "perimeter floating samples". The perimeter floating samples will be placed in areas where emitted asbestos fibers are most likely to be detected (downwind from work activities). Two potential worst-case scenario “area equivalent” samples will be collected on at least 2 workers who are expected to have the greatest potential exposure to asbestos during abatement operations. The results from these samples are for comparison to 0.01f/cc (and presence of asbestos for when analyzed by TEM) and should not be construed as “OSHA exposure assessment air samples”.

4. Eight (8) samples, including personnel and perimeter samples, will be submitted for PCM analysis. If analysis yields results with detectable fiber levels (based on fiber count) then TEM analysis will be conducted on two (2) highest PCM samples to evaluate engineering controls. After two (2) weeks of TEM sampling, the analytical results and engineering controls will be assessed to determine if adequate controls are in place. If controls are deemed adequate by UCD and CDPHE, the number of **TEM samples** may be reduced as approved by UCD and CDPHE. On an ongoing project basis, any sample with PCM results exceeding 0.01 fibers/cc must be analyzed by TEM. For large areas of disturbance, additional perimeter monitoring points shall be added if the active area of soil disturbance is larger than approximately 1 acre in size. One additional monitoring point should be added for each additional 200 linear feet of perimeter (approximately 1 sample per additional ¼ acre increase in area). For active areas of soil disturbance greater than 1 acre, additional samples shall be analyzed by TEM at a minimum rate of 25% of the total number of samples collected, based on highest PCM results. However, TEM analysis is not required if PCM results are non-detect (based on fiber count).

5. PCM verbal results will be made available by the start of the next business day or as soon as practical after the start of the next business day. TEM verbal results will be made available within 24-hours of receipt of samples by the laboratory, and written results will be made available within 24 hours from the time the verbal result is received. UCD and CDPHE will be immediately notified if any sample results show any concentration of airborne fibers. If any asbestos fibers are detected by TEM, all investigative activities will be stopped and engineering controls will be evaluated by Contractor and Consultant, and will be discussed with UCD and CDPHE to determine if changes in engineering controls or additional PPE are required.

14.9 **Personal Air Monitoring**

Air sampling of personnel is an employer based responsibility, and as such shall be the responsibility of each employer associated with soil disturbing activities. The “area equivalent” samples collected on personnel are interpreted as “worst case area” samples and are not intended to provide OSHA exposure information, but can be used by employers for general informational purposes.

14.10 **Truck/Container Staging/Lining and Waste Loading**

All truck drivers will be instructed to close all windows and shut-off air delivery systems (fans on air-conditioning and heating systems) when entering the loading area. All travel and positioning of waste transport Truck/Trailers on the site should be visually verified clean soil to minimize the need for decontamination procedures. At the loading location, install a ten-mil polyethylene sheeting or thicker “lay-down pad” that will be placed on the ground under
dumpsters/trucks to catch any spilled material. Spilled material will be cleaned up immediately and not allowed to dry out or accumulate. Additional poly shall be draped over trailer tires/fenders to minimize the need for decontamination after loading. After the load has been secured, and the load cover tarp is installed, the poly sheeting lay down loading pad will be properly decontaminated using wet wipe and or HEPA vacuuming methods. The loaded transportation truck may then proceed down the designated exit route.

To accomplish proper characterization of soil (preliminary visual inspection and verification visual inspection at staging area), movement of soil to staging areas for subsequent loading, transportation and disposal is necessary. Staged soil must be stabilized when loading is not occurring. Upon removal of staged ACS placed on “non-ACS area”, the contractor shall remove an additional 12 inches of soil to address any cross-contamination that may have occurred to the non-ACS area.

14.11 Waste Transportation and Disposal

Containers of friable asbestos waste, or asbestos-contaminated soil with visible friable asbestos, shall be labeled, in accordance with the requirements of Section 5.3 of the Solid Waste Regulations. In accordance with the disposal requirements for friable asbestos waste (Section 5.3.5(A) of the Solid Waste Regulations) at least two 6-mil polyethylene liners/sheeting shall be used for soil that contains visible friable asbestos. Polyethylene liners/sheeting should be designed and sized for the container to be used and should be folded over sides of trailers or containers to protect against contamination during loading and to facilitate decontamination. After loading, both liners/sheeting should be mechanically fasted and sealed separately. The liners/sheeting shall be sealed in a manner that ensures that they remain then leak-tight during transportation and disposal operations.

In addition, Department of Transportation (DOT) asbestos placards shall be placed on all four vertical sides of the container or vehicle being used for transport of ACM/ACS. The Contractor should direct the schedule of transportation of asbestos-contaminated soil. When loaded, each truck should be assigned a manifest to serve as the shipping document for that particular load.

Asbestos-contaminated soil shall be transported and disposed in a leak tight container in accordance with the CDPHE disposal requirements. Documentation stating that the soil originating from the site will not be used as daily cover or sold as clean fill shall accompany each load of asbestos-contaminated soil removed from the site.

Disposal of asbestos-contaminated soil will be conducted in accordance with the following requirements, in accordance with Section 5.5.7 of the Solid Waste Regulations:

1. Asbestos-contaminated soils containing visible friable asbestos will be disposed in a leak tight container as friable asbestos waste in accordance with the requirements of Section 5.3 of the Solid Waste Regulations.

14.12 Personnel Decontamination

A fully functioning 3-chamber decontamination trailer (or equivalent) will be placed outside the work zone to function as a remote shower location, with a clean room and an equipment room. All workers involved in removal/packaging of friable or significant quantities of nonfriable ACM will be double suited while in the work area and will shed one suit prior to leaving the work area and immediately proceed to the decontamination facility. All workers will decontaminate per OSHA regulations and CDPHE Regulation No. 8. Decontamination water will be filtered using a 5 micron filter, or in accordance with local requirements if more stringent, prior to disposal to the sanitary sewer.

14.13 Equipment Decontamination

All equipment and tools that come into contact with, or are used for removal of ACS will be decontaminated (free of all visible dust and debris) using wet cleaning (fire hose for trackhoe equipment, wet rags for hand tools, etc) and HEPA vacuuming methods (interior of equipment cab, etc), prior to leaving the work zone. Equipment decontamination will be conducted within a decontamination station constructed adjacent to the work zone. The
Decontamination station will be constructed of 10-mil polyethylene sheeting (and other materials as necessary, such as EPDM rubber roofing, etc) in such a way as to capture all contaminated material and wastewater from the decontamination process. All waste water from the decontamination station will be filtered to a minimum of 5-microns (or in accordance with local requirements if more stringent, prior to discharge to a sanitary sewer), or may be used for wetting ACS.

**14.14 Final Inspection Procedures**

As the project progresses, visual inspection will be performed to ensure that all observable asbestos-containing materials have been removed from the soil surface. During removal of soil, the soil will be removed in a manner that will provide a flat, even surface (with no spoil piles) for visual inspection. The inspections will be performed for the surface area removed that day, as a preliminary inspection. Due to the wet nature of the removal and the soil, adequate drying time is required before a final visual inspection can be conducted.

The removal of soil in the debris field area will be considered complete when the visible asbestos-containing material has been removed and an asbestos soil inspector makes a final decision that all contaminated soil in the debris field has been removed to depth and extent of excavation (where remaining visible material will be covered with a membrane and labeled), or depth of find plus 1 foot of soil (DOF+1) and extent of find plus 1 foot of soil (EOF+1).

**14.15 Managing ACS left in place**

Where visible asbestos containing material is observed at the depth and extent of excavation, 1 additional foot of soil shall be removed, the area shall be covered with a geotech membrane, labeled as asbestos contaminated soil, and then the membrane shall be covered with 1 foot of clean fill to bring back to desired grade/level. Prior to covering with clean fill, photographs will be collected from each compass point of the boundary, and the corner points of the boundary shall be obtained using measurements for a control point or with a GPS device.

**14.16 Spill Control**

Where asbestos contaminated soil is spilled during loading or transport, the Contractor shall immediately ensure the spilled material is immediately collected in accordance with wetting and emission control provisions of this SCMP. For spills that occur on clean soil, remove 12 inches of soil under spill area as precautionary measure. For spills that occur on hard surfaces such as asphalt roadways or concrete parking lots, provide wet cleaning and HEPA vacuuming until all visible dust and debris have been removed.

Where water run-off occurs resulting in visible erosion and sediment transfer from asbestos contaminated soil areas to non-asbestos contaminated soil areas, remove top 12 inches of soil where the visible erosion and sediment deposition occurred.

**14.17 Erosion Control**

To control wind erosion of ACS, use of silt fencing or wind fencing may be used, where appropriate. Stabilize asbestos containing soil with friable debris by covering with magnesium chloride (or equivalent soil stabilizer) or 6-mil poly until removal can occur. Securely fasten poly sheeting to prevent removal by the wind.

To control water erosion, the use of silt fencing, erosion control mats, straw waddles or equivalent erosion control methods shall be used in areas where run-off is likely. Where ACS will remain, cover with geotech membrane, and then cover with 12 inches of clean fill and cover with appropriate vegetative growth or ground cover to prevent erosion.
15 Special Considerations

15.1 Emergency Buried Utility Repair Projects

Specific provisions of this SOP require some planning and response time that may not be appropriate in an emergency response situation to repair a buried utility. This section identifies the minimum requirements under this SOP for the first 24 hours of excavation and repair, to ensure that necessary repairs can be made to buried utilities promptly in an emergency situation where the utility must be repaired immediately (which may include evening and weekend work), where ACS is encountered during the emergency response, only worker protection, adequate wetting and no visible emission provisions of this SOP will apply within the first 24 hours, with remaining provisions including material characterization, soil training, air monitoring, disposal, etc to take effect after the first 24 hours of the excavation and repair. By ensuring adequate wetting and no visible emissions during emergency excavation during the first 24-hours, this will allow necessary work to continue, and will provide a window for implementing remaining provisions of this SOP including testing of suspect materials and where ACS is identified, and for implementing management actions under this SOP. Where suspect material is identified in soil that has been excavated during the emergency repair, this soil shall not be placed back into the hole/pit until characterization can be conducted by an asbestos soil inspector.

15.2 Importing and Exporting Soil

The Contractor shall notify and receive approval from the UCD project manager prior to any soil being exported or imported to the project. Contractor shall coordinate any inspections, spotting, or testing requested by the UCD project manager for any exported or imported soils to the project.

15.3 Building Demolition Debris Removal Verification

To ensure demolition debris is removed during the demolition phase in accordance with applicable regulations, an asbestos soil inspector will conduct a site inspection during the final stage of demolition to determine if all demolition debris has been removed. As a precautionary measure, as part of the final demolition site cleaning, a layer of clean soil should be removed to ensure no construction debris remains upon completion of the demolition process as verified by inspection by an asbestos soil inspector, with the exception of non-asbestos-containing/contaminated “structural” fill such as concrete and brick as approved by UCD.

15.4 Soil Stockpiling Management Procedures

Stockpiling of asbestos contaminated soils will only occur under CDPHE and UCD approval, as removal of contaminated soil will be under a direct load approach unless otherwise approved by UCD and CDPHE. When soil movement and stockpiling is necessary, based on site logistics, stockpiled soil must be stabilized and covered when not in use, and must not be allowed to remain on site longer than 5 working days.

For excavation and stockpiling of non-asbestos contaminated soils that are subject to “soil spotting provisions” (moderate to high potential ACS), an asbestos soil inspector will be present at all areas where stockpiled soils are placed, and will be in radio communication with the asbestos soil inspector inspecting soils at the excavation point to ensure prompt and efficient response to discovery of visible ACM debris at either location.

15.5 Management Practices for Significant Discovery of only Nonfriable materials

Where only nonfriable materials are observed (no friable debris) in a significant discovery “debris field”, the following are required procedures:

1. Ensure material and soil is adequately wet and no visible emission occur during excavation and loading activities.
2. Packaging and disposal as nonfriable asbestos containing waste material.

15.6 Soil Sampling

The primary method for determining asbestos contaminated soil under this SOP and under CDPHE HMWMD regulation is visual identification of suspect material that is confirmed or presumed to be asbestos. Soil sampling is considered an optional activity and will be conducted only with UCD written authorization to conduct soil sampling on the campus. There are two primary situations where UCD may authorize soil sampling:

1. Soil sampling to provide general information about imported or exported soils as part of the management procedures under the SOP.
2. UCD written authorization to conduct soil sampling in conjunction with “Remediation” actions (as provided in Attachment #5) conducted to remove the full extent and depth of asbestos contaminated soil from a specified area. Remediation soil sampling may include “baseline” characterization for soil sampling collected prior to a remediation action, and will include collection of “clearance” (post-removal) soil sampling to verify removal of all asbestos (including trace amounts in soil as determined by PLM analysis).

Refer to Attachment #4 for surface soil sampling and analysis procedures.

15.7 Remediation

If the objective of an ACS removal activity is remediation of a specific location to remove the complete extent and depth of asbestos in soil at a specific location, including trace in soil as determined by PLM analysis, or for the purpose of obtaining a no further action determination under some other regulatory framework, such work must be in accordance with the remediation plan provided as a supplement to this SOP in Attachment #5. The remediation plan integrates the sampling and analysis plan (SAP) provided in Attachment #4 and describes soil handling and soil clearance (visual and bulk sampling) criteria. Refer to Attachment #5 for surface remediation procedures.

16 Project Reporting

Upon completion of soil disturbing activities, to aid in future management of site and any remaining ACS conditions known to exist, a close out report will be provided to the UCD to document work performed, and any ACS material known to exist that will remain for management.

The project close-out report shall include the following minimum components:

1. Property description and description of areas with asbestos-contaminated soils
2. Description of soil disturbing activities involving ACS (emission control procedures) and non-ACS conditions
3. Description of all field operations or daily logs
4. Containment logs (where appropriate)
5. Air Monitoring logs and analytical results associated with ACS removal actions
6. Description/results of all asbestos bulk sampling events, including sample locations descriptions and sample diagram/drawing showing sample locations
7. Analytical results associated with bulk sampling events
8. Disposal summaries and manifests
9. Maps showing excavation profiles
10. Documentation of asbestos left in place including drawings, photographs and GPS coordinates for corner points of known ACS.
11. Photographs showing pre-, during and post excavation/removal conditions
12. Accreditation and Certification documentation for activities covered under the Work Plan (Inspector, Air Monitoring Specialist, Supervisor, and Worker)
17 SOP Review and Revision

17.1 SOP Review
Annually, the UCD Facilities Planning Department contact and UCD Environmental Health and Safety Division contact as provided in Section 3 of this SOP shall review this SOP with an asbestos accredited/certified Project Designer with 6-month asbestos soil experience to identify any needed revisions to this SOP.

17.2 SOP Review
Based on annual review, any revisions to the SOP shall be submitted to CDPHE as a “revised” SOP with a new revision number and revision date for CDPHE review and approval.

18 Attachments

Attachment #1  ACS Classification and AMC Boundary Drawing (and Site Survey Drawings)
Attachment #2  Historical Buildings and Steam Tunnels Site Drawing
Attachment #3  SOP Flow Chart
Attachment #4  Soil Sampling and Analysis Plan (SAP)
Attachment #5  Remediation Plan
Attachment #6  CDPHE Notification Summary and Notification Forms
ATTACHMENT 1

ACS CLASSIFICATION AND AMC BOUNDARY
SITE DRAWING AND SITE SURVEY DRAWINGS
ATTACHMENT #2

HISTORICAL BUILDING AND STEAM TUNNEL
SITE DRAWING
ATTACHMENT #3

SOP FLOW CHART
ATTACHMENT #4

SOP SUPPLEMENTAL PROCEDURES
SOIL SAMPLING AND ANALYSIS PLAN (SAP)

General

1. Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
2. When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the boring from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
3. A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
4. Proper chain-of-custody protocols should be followed for all samples collected.

Analytical Procedures

1. Soil samples should be analyzed by PLM for bulk asbestos samples (Method – EPA/600/R-93/116). The samples should be homogenized by the laboratory prior to sample analysis.

Surface Soil Sampling

1. Divide the area to be inspected into a grid, using stakes or paint to mark grid nodes. The area of each grid square will be determined based on the size of the site, and existing knowledge of the extent and concentration of surface asbestos;
2. Grids are (50’ x 50’) on an X and Y axis utilizing planned north with the south west corner of each grid being the reference point for each grid site wide. X axis designation is numerical and Y axis grid designation is alphabetical.
3. Each grid point is identified in the lower left (Southwest) corner with a 48” wood lathe with pink ribbon alpha numerically (i.e. B15, CA12).
4. Sub-grids (25’ x 50’) rectangle grids within each (50’ x 50’) grid are identified with pin flags alpha numerically (i.e. B15-1, CA12-2).
5. Where grids extend beyond a scope of work boundary and/or property boundary, this boundary will be designated with a string line to delineate scope in partial grids (where grids overlay on scope of work or property boundary).
6. Using flags, paint or GPS, mark locations of any suspected asbestos found;
7. Record locations of suspected asbestos found using a map, log or other documentation. The absence of asbestos in a grid square will also be documented;
8. Place suspected asbestos material in a sample bag, adequately wetting it prior to disturbing it; and record time and date, location and description of material collected.
9. A composite aliquot soil sample will be collected within each sub-grid 1,250 square feet (25’ x 50’) by an asbestos soil inspector. The asbestos soil inspector will collect ten aliquots of surface soil (top 1 inch) within each sub-grid. Two sample aliquots will be collected from the southwest quadrant, southeast quadrant, northwest quadrant, northeast quadrant, and the relative center of
the sub-grid (totaling ten aliquots per sub-grid). A grid will be considered an asbestos
contaminated soil grid where soil sampling data reports the presence of asbestos in any sub grid
within that grid (thus progressive analysis may be used to create sample sets for each grid, with a
positive stop used where analysis shows asbestos present (eliminating the need to analyze the
second sub grid).

10. Samples will be placed in a sample jar, labeled, and location, time, date will be documented.
11. The sample will be homogenized at the laboratory;
12. Follow proper chain of custody protocols.

Subsurface Soil Sampling - Borings

1. A composite sample should be collected from each soil boring. The sample should be made up of
five (5) to ten (10) aliquots representative of the soil boring. The actual number of aliquots may
vary depending on the depth of sampling and the conditions observed.

Subsurface Soil Sampling – Potholes and Trenches

1. Collect a composite sample made up of five (5) to ten (10) aliquots representative of the soil
encountered in the trench or pothole. The actual number of aliquots may vary depending on the
depth of sampling and the conditions observed. In addition, it may be warranted to collect
separate samples from various strata, with aliquots collected from individual strata, to better
characterize observed conditions.

Informational Soil Samples for Imported/Exported Soil

1. The asbestos soil inspector will collect composite samples comprised of 10-point aliquots from
10% of the total number of loads dumped (for imported soils) and/or loaded (for exported soils).
Soils sampled for informational purposes shall be managed in an appropriate manner (stockpiled
by day, area, etc) to allow appropriate management of soil based on soil sampling data. All soil
samples will be submitted to an accredited laboratory for PLM analysis on a “rush” turnaround.

Interpretation of Sampling Data

1. Samples reporting no asbestos detected shall be interpreted as non-ACS, and samples reporting
the presence of asbestos shall be considered ACS.
Where the intent is to remediate (removal all visible debris and asbestos in soil to a concentration of no asbestos detected in the soil, based on soil sampling), the following supplement to the SOP provides specific remediation provisions.

The following provisions identified in Section 12 of the SOP shall apply to ACS surface soil remediation (soil removal, packaging, transportation and disposal) procedures:

- Notifications Planned Asbestos-contaminated Soil Disturbance
- Limited Quantity Discovery Management and Disposal
- Site Control, Demarcation, Fencing and Wind Screening
- Protection of Adjacent Structures
- Soil Wetting and Stabilization
- Dust and Emissions Control
- PPE
- Equipment/Engineering Controls
- Removal/Excavation
- Soil Stockpiling
- Wind and Work Stoppage Conditions
- Environmental Monitoring
- Personal Air Monitoring
- Truck/Container Staging/Lining and Waste Loading
- Waste Transportation and Disposal
- Personnel Decontamination
- Equipment Decontamination
- Final Inspection Procedures

All ACS identified based on visual characterization (extent and depth) of find, shall be removed plus an additional 12 inches of soil beyond the extent of find (EOF) and 12 additional inches beyond the depth of find (DOF) which identifies the 3-dimensional box of soil removed under the remediation.

After removal to EOF and DOF based on visual and preliminary soil sampling data, post remediation “surface clearance” soil sampling will be conducted in accordance with the Soil Sampling and Analysis Plan (Attachment #4) of this SOP, on a grid by grid basis. Any grid reporting the presence of asbestos will be considered to have “failed” and will require removal of additional twelve (12) inches of soil, and the “clearance process will be repeated until “no asbestos detected” is reported for that grid, after which that grid will then have deemed to “pass”. Once all grids in the delineated area have been characterized, remediated, and passed “clearance soil testing”, the remediation action will be considered complete.
ATTACHMENT #6

CDPHE HMWMD NOTIFICATION SUMMARY AND NOTIFICATION FORMS
April 28, 2010

Mr. Ken Neeper
Manager Infrastructure Development
University of Colorado Denver
Mail Stop F418
1945 North Wheeling Street
Aurora, CO 80045

RE: Asbestos-Contaminated Soil (ASC) Management, Standard Operating Procedure (SOP) Document,
University of Colorado Denver Anschutz Medical Campus, February 26, 2010

Dear Mr. Neeper,

The Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division (the “Division”), has received and reviewed the above referenced standard operating procedures for the proper management of asbestos-contaminated soils during soil disturbing activities at the Anschutz Medical Campus of the University of Colorado Denver. The Anschutz Medical Campus is located on the site of the former Fitzsimons Army Medical Center in Aurora, Colorado. The Division has no additional comments and hereby approves the Anschutz Medical Campus ACS Management SOP Document.

If you have any further questions or comments please contact me at 303-692-3416 or via e-mail at jeffrey.swanson@state.co.us.

Sincerely,

Jeffrey R. Swanson, P.E.
Federal Facilities Restoration and Reuse Unit
Remedial Program

CC: Tom Butts, Walsh Environmental Scientists and Engineers
    Monica Sheets, CDPHE
    Rob Eber, AGO
    File Copy: RD007-13.1
SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Concrete mixtures for concrete slabs and concrete deck fill shall be normal weight and shall have a water-cement ratio of 0.45 or less.
   2. Provide sheet vapor retarder directly below concrete at all slabs-on-grade.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete Materials:
   1. Portland Cement Replacement: Fly ash to reduce portland cement up to 40 percent is acceptable for concrete mixtures for footings, foundation walls, walls, columns, and other vertical surfaces; not permitted for slabs.

B. Sheet Vapor Retarder: ASTM E 1745, Class A, 15 mil, except with maximum perm rating of 0.01. Include manufacturer’s recommended adhesive or pressure-sensitive tape. Provide at all slabs-on-grade.

C. Penetrating Liquid Floor Treatments: Clear, chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces. Provide at loading docks, receiving areas, and other similar exposed concrete floor surfaces subject to heavy, hard-wheeled devices.

D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor and Slab Finishes:
   1. Trowel: Surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or thin-film-finish coating system.

3.2 FIELD QUALITY CONTROL

A. Testing: By The University-engaged agency.

B. Special Inspections: By The University-engaged special inspector.

C. Cost of Testing: To be included as part of Project budget.

END OF SECTION 03 30 00
SECTION 03 38 16 - UNBONDED POST-TENSIONED CONCRETE

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS:

A. Design Requirements:
   1. The use of post-tensioned concrete must be specifically approved by the University facilities projects and CBO through the University Project Manager.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 03 38 16
SECTION 04 01 20 - MAINTENANCE OF UNIT MASONRY

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Restoration specialist: Prequalified firm having not less than 5 years successful experience in comparable masonry restoration projects and employing personnel skilled in the restoration processes and operations required by the Project.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 04 01 20
SECTION 04 20 00 - UNIT MASONRY

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. All exterior unit masonry walls shall be designed as cavity walls with protected weather-resistive barrier on the drainage plane, adequate cavity ventilation to encourage drying, and sufficient weeps and thru-wall flashing and all cavity interruptions. Single-wythe exterior masonry walls are not permitted.
   2. All exterior masonry to be reviewed and approved by the University of Colorado Design Review Board and the University Campus Architect.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete Masonry Units (CMUs): Normal weight.

B. Brick: Face brick, Grade SW.

C. Masonry Joint Reinforcement:
   1. Interior Walls: Hot-dip galvanized, carbon steel.
   2. Exterior Walls: Stainless steel.

D. Ties and Anchors: Stainless steel.
   1. Adjustable Masonry-Veneer Anchors: Screw attached.

E. Embedded Flashing:
   1. All Flashing: Stainless steel preferred.
   2. Concealed (Flexible) Flashing: Rubberized asphalt.
      a. Used with stainless steel drip edge acceptable.

F. Weep/Vent Holes: Cellular plastic or plastic mesh.

G. Cavity drainage material: Provide in all cavity walls to protect clogging weeps with mortar drippings.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Mortar Net USA, Ltd.; Mortar Net or a comparable product.

H. Cavity-Wall Insulation: Extruded-polystyrene board.

I. Mortar:
   1. Portland cement-lime mortar unless otherwise indicated.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 04 20 00
SECTION 05 31 00 - STEEL DECKING

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Roof Deck: Galvanized-steel sheet.
B. Composite Floor Deck: Prime-painted steel sheet.
C. Noncomposite Form Deck: Galvanized-steel sheet.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Deck: Welded.
B. Floor Deck: Welded.

END OF SECTION 05 31 00
SECTION 05 40 00 - COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Performance Requirements:
   1. Deflection Limits: L/360 typical except L/720 at backup wall framing supporting exterior masonry veneer.

B. Engineering design of cold-formed metal framing by Contractor.

1.2 DEFINITIONS

A. Cold-formed metal framing includes:
   1. Exterior and interior load-bearing wall framing.
   2. Exterior non-load-bearing wall framing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Sheet: ASTM A 1003/A 1003M, Structural Grade, G90, metallic coated.

B. Load-Bearing Wall Framing: Standard C-shaped, punched steel studs and U-shaped, unpunched track.
   1. Minimum Steel Thickness: 0.054 inch (16 gauge).

   1. Minimum Steel Thickness: 0.054 inch (16 gauge).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten framing by welding or screw fastening.
   1. Load-Bearing Wall Stud Spacing: 16 inches maximum.

END OF SECTION 05 40 00
SECTION 05 51 00 - METAL STAIRS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide preassembled steel stairs with concrete-filled treads at all back-of-house stairs.
   2. Provide industrial-type stairs with steel floor plate or grating treads only where approved by the University Project Manager.
   4. For pre-assembled and industrial-type stairs, provide both high-performance coated steel tube railings attached to metal stairs and high-performance coated steel tube handrails attached to walls adjacent to metal stairs as required by design.
   5. See Section 05 73 00 – Decorative Metal Railings for handrails and guardrails at ornamental steel-framed stairs.

B. Performance Requirements:
   1. Engineering design of steel stairs and railings by Contractor.

1.2 QUALITY ASSURANCE

A. Stair Standard: NAAMM AMP 510, "Metal Stairs Manual."
   1. Preassembled Stairs: Commercial class.
   2. Industrial-Type Stairs: Industrial class.
   3. Ornamental Stairs: Architectural class.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stringers: Steel plates or channels.

B. Metal-Pan Stairs: Uncoated cold-rolled steel sheet.

C. Metal Bar-Grating Stairs: 5/16 inch maximum opening.

D. Steel Tube Railings:
   1. Rails and Posts: Manufacturer’s standard for preassembled stairs.
   2. Picket Infill: 1/2-inch- square pickets spaced less than 4 inches clear. Horizontal rails not permitted.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 05 51 00
SECTION 05 73 00 - DECORATIVE METAL RAILINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

   A. Design Requirements: Handrails to be fabricated from metal not requiring hand painting.

PART 2 - PRODUCTS

2.1 MATERIALS

   A. Aluminum.

   B. Copper Alloys: Bronze, brass, copper, or nickel silver.

   C. Stainless Steel: Type 304 at interior; Type 316 at exterior.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 05 73 00
SECTION 06 10 53 - MISCELLANEOUS ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
   1. Wood studs not permitted. If required and approved by the University Project Manager provide
      fire-retardant-treated lumber.
   2. Select composite wood products with low emissions based on ASTM testing standards E1333-10.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wood Products, General:
   1. Maximum Moisture Content of Lumber: 15 percent for 2-inch nominal thickness or less, 19
      percent for more than 2-inch nominal thickness.

B. Wood-Preservative-Treated Materials:
   1. Preservative Treatment: AWPA U1; use Category UC2 except use Category UC3b for exterior
      construction and use Category UC4a for items in contact with the ground.
      a. Preservative Chemicals: Containing no arsenic or chromium.
   2. Application: Items indicated and the following:
      a. Items in contact with roofing or waterproofing.
      b. Items in contact with concrete or masonry.
      c. Framing less than 18 inches above ground in crawlsaces.
      d. Floor plates installed over concrete slabs-on-grade.

C. Fire-Retardant-Treated Materials:
   1. Exterior type for exterior locations and where indicated.
   2. Interior Type A, High Temperature (HT) for enclosed roof framing and where indicated.
   3. Interior Type A unless otherwise indicated.

D. Miscellaneous Lumber:
   1. Dimension Lumber: Construction or No. 2 grade any species.

E. Plywood Backing Panels: Exterior, AC, fire-retardant treated.

F. Fasteners: Hot-dip galvanized steel where exposed to weather, in ground contact, in contact with treated
   wood, or in area of high relative humidity.

PART 3 - EXECUTION (Not Applicable)
SECTION 06 16 00 - SHEATHING

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wall Sheathing:

B. Wood Sheathing: Plywood, oriented-strand board, fiberboard or any wood-based sheathing products are not permitted.

C. Miscellaneous Materials:
   1. Sealant for gypsum sheathing.
   2. Sheathing tape.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Gypsum Sheathing:
   1. Screw to cold-formed metal framing.
   2. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing joints and apply and trowel silicone emulsion sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.

END OF SECTION 06 16 00
SECTION 06 20 23 - INTERIOR FINISH CARPENTRY

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Shelving: MDO plywood with wood edge; AWI custom grade; 1 inch thick minimum.

B. Shelving Standards: Provide standard-duty except where heavier loads are anticipated.
   1. Standard-duty standards: BHMA A156.9, B4102
      a. Basis-of Design Product: Subject to compliance with requirements, provide Knape & Vogt 80 Series Standard System or comparable product.
   2. Standard-duty brackets: BHMA A156.9, B4112
      a. Basis-of Design Product: Subject to compliance with requirements, provide Knape & Vogt 180 Series Bracket System comparable product.
   3. Heavy-duty standards: BHMA A156.9, B4102
      a. Basis-of Design Product: Subject to compliance with requirements, provide Knape & Vogt 85 Series Standard System or comparable product.
   4. Heavy-duty brackets: BHMA A156.9, B4112
      a. Basis-of Design Product: Subject to compliance with requirements, provide Knape & Vogt 185 Series Bracket System comparable product.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 06 20 23
SECTION 06 41 00 – ARCHITECTURAL WOOD CASEWORK

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Wood cabinets not permitted in wet areas.
   2. Comply with AWI standard; grade as indicated.

PART 2 - PRODUCTS

2.1 WOOD-VENEER-FACED ARCHITECTURAL CABINETS

A. WOOD CABINETS FOR TRANSPARENT FINISH
   1. Grade: AWI Premium preferred; AWI Custom acceptable based on Project cost.
   2. Type of Construction: Frameless.
   3. Cabinet and Door and Drawer Front Interface Style: Flush overlay.
   4. Wood for Exposed Surfaces:
      a. Species: White birch or as approved by the University Project Manager.
      c. Veneer Matching: Book match veneer leaves and center-balance match within panel face.
         1) Cabinet veneers in each space from a single flitch.
   5. Cabinet Interior (not exposed to view): Thermoset decorative panels.

B. MATERIALS
   1. Cabinet Hardware:
      a. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 100 degrees of opening.
      b. Wire Pulls: Back mounted, solid metal, 4 inches long, 5/16 inch in diameter.
      c. Heavy Duty Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081.
      d. Shelf Rests: BHMA A156.9, B04013; metal; for normal duty cabinet shelving.
      e. Catches: Magnetic catches, BHMA A156.9, B03141.
      f. Drawer Slides: BHMA A156.9, B05091.
         1) Heavy Duty (Grade 1HD-100 and Grade 1HD-200): Side mounted; full-extension type; zinc-plated steel ball-bearing slides.
         2) Box Drawer Slides: Grade 1HD-100; for drawers not more than 6 inches high and 24 inches wide.
         3) File Drawer Slides: Grade 1HD-200; for drawers more than 6 inches high or 24 inches wide.
         4) Pencil Drawer Slides: Grade 1; for drawers not more than 3 inches high and 24 inches wide.
         5) Keyboard Slides: Grade 1HD-100; for computer keyboard shelves.
         6) Trash Bin Slides: Grade 1HD-200; for trash bins not more than 20 inches high and 16 inches wide.
      g. Door Locks: BHMA A156.11, E07121; where indicated and approved by the University Project Manager.
      h. Drawer Locks: BHMA A156.11, E07041; where indicated and approved by the University Project Manager.
      i. Track for Sliding Doors:
      j. Offset Carrier for Sliding Doors:
      k. Cam Locks: Basis-of-design product; National, C8103.
      l. Grommets for Cable Passage through Countertops: 2-inch OD, molded-plastic grommets and matching plastic caps with slot for wire passage.
m. Exposed Hardware Finishes: Satin chromium plated; BHMA 626 (US26D).

C. SHOP FINISHING
1. Grade: Same grade as woodwork.
2. Extent: All cabinets shop finished.

2.2 PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS

A. WOOD CABINETS FOR OPAQUE FINISH
1. Grade: AWI Premium preferred; AWI Custom acceptable based on Project cost.
2. Type of Construction: Frameless.
3. Cabinet and Door and Drawer Front Interface Style: Flush overlay.
4. Laminate Cladding for Exposed Surfaces:
   a. Horizontal Surfaces: Grade HGS.
   b. Postformed Surfaces: Grade HGP.
   c. Vertical Surfaces: Grade HGS.
5. Cabinet Interior: Thermoset decorative panels.

B. MATERIALS
1. Cabinet Hardware: Same as for wood-veneer-faced architectural cabinets.

2.3 PLASTIC-LAMINATE COUNTERTOPS

A. Materials:
1. High-Pressure Decorative Laminate Grade: HGS.
3. Backer Sheet: Provide plastic-laminate backer sheet, Grade BKL, on underside of countertop substrate.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 06 41 00
SECTION 06 42 16 - FLUSH WOOD PANELING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements: Wood paneling is permitted as an interior wall finish if approved by the University - CBO through the University Project Manager.

PART 2 - PRODUCTS

2.1 FLUSH WOOD PANELING FOR TRANSPARENT FINISH

A. Grade: Premium.
B. Species: White birch or as approved by the University Project Manager.
C. Cut: Quarter cut/quarter sawn or as approved by the University Project Manager.
D. Panel Matching: As proposed by Designer and approved by the University Project Manager.
E. Fire-Retardant-Treated Paneling: Flame-spread index of 25 or less.

2.2 SHOP FINISHING

A. Grade: Premium for transparent finish.
   1. Finish: System - 11, catalyzed polyurethane.
B. Extent: All paneling shop finished.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 06 42 16
SECTION 07 10 00 - DAMPROOFING AND WATERPROOFING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Damproof all footings, stem walls and grade beams.

B. Waterproof all basement level foundation walls.
   1. Hot fluid-applied rubberized asphalt waterproofing preferred; self-adhering modified bituminous
      sheet waterproofing acceptable.
   2. Provide HDPE sheet waterproofing at blind-side applications; bentonite panel waterproofing not
      acceptable.

C. Waterproof all below grade tunnel roofs and all plazas decks over occupied space with hot fluid-applied
   rubberized asphalt waterproofing.

D. Provide board insulation and protection course at all foundation walls.

PART 2 - PRODUCTS

2.1 DAMPROOFING

A. Cold-applied, emulsified-asphalt dampproofing.

2.2 SELF-ADHERING MODIFIED BITUMINOUS SHEET WATERPROOFING

A. Modified Bituminous Sheet: Minimum 60-mil nominal thickness, self-adhering sheet consisting of 56
   mils of rubberized asphalt laminated on one side to a 4-mil- thick, polyethylene-film reinforcement, and
   with release liner on adhesive side
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. American Hydrotech, Inc. VM75.
      b. Grace, W.R., & Co.; Bituthene 3000/Low Temperature or Bituthene 4000.

2.3 HOT FLUID-APPLIED RUBBERIZED ASPHALT WATERPROOFING

A. Hot Fluid-Applied, Rubberized-Asphalt, Reinforced Waterproofing Membrane: Single component; 100
   percent solids; hot fluid-applied, rubberized asphalt.
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. Tremco Incorporated; Tremproof 6100.

2.4 BONDED HDPE SHEET WATERPROOFING

A. Bonded HDPE Sheet for Vertical Applications: Uniform, flexible, multilayered-composite sheet
   membrane consisting of either a HDPE film coated with a pressure-sensitive adhesive and protective
   release liner, total 32-mil thickness.
   1. Basis-of-Design Product: Subject to conformance with requirements, provide W.R. Grace & Co.
      Preprufe 160R or comparable product.
B. Bonded HDPE for Horizontal Applications: Uniform, flexible, multilayered-composite sheet membrane consisting of an HDPE film coated with pressure-sensitive adhesive and protective release liner, total 46-mil thickness.

1. Basis-of-Design Product: Subject to conformance with requirements, provide W.R. Grace & Co. Preprufe 300R or comparable product.

2.5 MOLDED-SHEET DRAINAGE PANELS

A. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite subsurface drainage panel consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 sieve laminated to one side of the core and a polymeric film bonded to the other side; and with a vertical flow rate of 9 to 15 gpm per ft.

2.6 INSULATION

A. Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi minimum compressive strength; square or shiplap edged.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 10 00
SECTION 07 18 00 - TRAFFIC COATINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide traffic coating on all mechanical room floors.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Traffic Coating: For equipment-room-floor application.
   1. Manufacturer: Subject to compliance with requirements, provide products from one of the following:
      a. Carlisle Coatings & Waterproofing, Inc.
      b. Neogard; Division of Jones-Blair.
      c. Tremco Incorporated; an RPM company.
   3. Preparatory and Base Coats: Aromatic urethane.
      a. Aggregate: As recommended by manufacturer.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 18 00
SECTION 07 21 00 - THERMAL INSULATION

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. R-value of roofs, walls, and floors shall be not less than the prescriptive requirements of
      ASHRAE 90.1, latest edition. Lower R-values are not permitted even if International Energy
      Code Compliance can be demonstrated using the energy model approach.
   2. Wherever possible continuous insulation is encouraged.
   3. Provide WUFI moisture analysis of all exterior wall and roof assemblies to determine and justify
      the appropriate placement of a vapor retarder within the assembly.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Insulation:
   1. Extruded-Polystyrene Board: Type IV, 25 psi.
   3. Unfaced Glass-Fiber Blanket: Type I.
   4. Closed-Cell Spray Polyurethane Foam: Type II, minimum density of 1.5 lb/cu. ft.

B. Vapor Retarders: Reinforced polyethylene.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 21 00
SECTION 07 24 00 - EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS)

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Exterior insulation and finish systems are not permitted.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 24 00
SECTION 07 27 00 - AIR BARRIERS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Design building envelope to provide a continuous, uninterrupted air barrier.
   2. The air barrier may also serve the function of the weather-resistive barrier.
   3. Provide WUFI moisture analysis to determine if the air barrier should be vapor-permeable or vapor-impermeable.
   4. Where air barrier material is applied to the exterior sheathing, the air barrier material may be either fluid-applied or self-adhering sheet.

PART 2 - PRODUCTS

2.1 SELF-ADHERING, VAPOR RETARDING SHEET AIR BARRIER

A. Products: Subject to compliance with requirements, provide one of the following:
   2. Henry Company; Blueskin SA.
   3. Tremco Incorporated, an RPM company; ExoAir 110.

2.2 SELF-ADHERING, VAPOR PERMEABLE SHEET AIR BARRIER

A. Products: Subject to compliance with requirements, provide one of the following:
   2. Henry Company; Blueskin VP 160.
   3. VaproShield; WrapShield SA.

2.3 FLUID-APPLIED, VAPOR RETARDING MEMBRANE AIR BARRIER

A. Products: Subject to compliance with requirements, provide one of the following:
   1. Henry Company; Air-Bloc 06.
   2. Meadows, W.R. Inc.; Air-Shield LM.
   3. Tremco Incorporated, an RPM company; ExoAir 120SP/R.

2.4 FLUID-APPLIED, VAPOR PERMEABLE MEMBRANE AIR BARRIER

A. Products: Subject to compliance with requirements, provide one of the following:
   2. Henry Company; Air-Bloc 31.
   3. Tremco Incorporated, an RPM company; ExoAir 230.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air barrier and all transition strips, flashings, sealants and other accessories necessary to provide a continuous air barrier.

END OF SECTION 07 27 00
SECTION 07 42 13 - METAL WALL PANELS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
1. Design all metal wall panels as cladding only. Provide complete weather-resistive and air-barrier membrane over solid sheathing with drainage plane and weeps behind the cladding.
2. Metal wall panel type, configuration, profile, etc. to be approved by the University Project Manager.

B. Performance Requirements:
1. Deflection Limits: 1/180 of span.
2. Air Infiltration: Not more than 0.06 cfm/sq. ft when tested at 6.24 lbf/sq. ft.; ASTM E 283.
3. Water Penetration: None, when tested at 6.24 lbf/sq. ft.; ASTM E 331.

PART 2 - PRODUCTS

2.1 FORMED METAL WALL PANELS

A. Exposed-Fastener or Concealed-Fastener, Lap-Seam Metal Wall Panels
1. Material: Metallic-coated steel or aluminum.
2. Exterior Finish: Three-coat fluoropolymer.

2.2 METAL PLATE WALL PANELS

A. Metal Plate Wall Panels:
1. Material: Tension-leveled, smooth aluminum sheet, 0.125 inch thick minimum.
2. Exterior Finish: Three-coat fluoropolymer.
3. Attachment Assembly: Rainscreen principle.

2.3 METAL COMPOSITE MATERIAL WALL PANELS

A. Metal Composite Material Wall Panels
1. Material: Aluminum faced; 0.157 inch (4mm) thick; fire-retardant core.
2. Exterior Finish: Three-coat fluoropolymer preferred.
3. Attachment Assembly: Rainscreen principle.

2.4 INSULATED METAL WALL PANELS

A. Concealed-Fastener, Foamed-Insulation-Core Metal Wall Panels
2. Exterior Finish: Three-coat fluoropolymer.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 42 13
SECTION 07 50 00 - MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
1. Provide fully-adhered membrane roofing for all new construction.
2. PVC or KEE membrane preferred; TPO acceptable if project budget does not permit PVC or KEE.
3. For renovation work, consider matching existing roofing system or separate new construction from existing in order to preserve the warranty on the existing roof.
4. Provide walkway treads from roof access points continuous to and around all roof mounted equipment.
5. Design scuppers, downspouts and overflow drains so that they do not discharge down the face of the building or across a sidewalk.
6. Provide splash blocks to control and direct downspout and overflow drain discharge at grade.
7. Locate overflow drain wall hydrants so that they do not discharge across pedestrian travel paths.
8. Provide positive slope to drain on all roofs.

B. Performance Requirements:
1. Roofing System Design: Uplift pressures calculated according to ASCE/SEI 7.
2. FM Approvals Listing: Class 1A-90 minimum.
3. Exterior Fire-Test Exposure: Class A.

1.2 WARRANTY

A. Special Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period.
1. Special warranty includes membrane roofing, base flashings, roof insulation, fasteners, cover boards, substrate board, roofing accessories, roof pavers, and other components of membrane roofing system.
2. Warranty Period: 20 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, signed by Installer, covering the Work of this Section, including all components of membrane roofing system such as membrane roofing, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, roof pavers, and walkway products, for the following warranty period:
1. Warranty Period: 5 years from date of Substantial Completion.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect and cover membrane and board insulation with tarpaulins.

B. Store adhesives at temperatures between 50 deg-F and 80 deg-F.

PART 2 - PRODUCTS

2.1 ROOFING MEMBRANE

A. PVC membrane roofing:
1. PVC Sheet: ASTM D 4434, Type II, Grade I, glass fiber reinforced.
   a. Products: Provide the following:
      1) Sarnafil Inc.; Sarnafil G410.
   b. Thickness: 60 mils.
   c. Exposed Face Color: Light color with SRI not less than 78.

B. KEE membrane roofing:
      a. Products: Provide the following:
         1) Seaman Corporation.; Fibertite-SM.
      b. Thickness: 60 mils.
      c. Exposed Face Color: Light color with SRI not less than 78.

C. TPO membrane roofing:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Carlisle SynTec Incorporated.
         2) Firestone Building Products Company.
         3) Johns Manville.
      b. Thickness: 60 mils.
      c. Exposed Face Color: Light color with SRI not less than 78.

2.2 ROOF INSULATION

A. Substrate Board: Glass-mat, water-resistant gypsum board.

B. Vapor Retarder: If required, self-adhering, rubberized asphalt.

C. Roof Insulation: Polyisocyanurate board.

D. Cover Board: Primed, glass-mat, water-resistant gypsum substrate.

2.3 WALKWAYS

A. Flexible Walkways: Roofing manufacturer’s recommended, factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway rolls.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Seams: Provide thermally welded membrane patch at all membrane joints with three or more edges.

3.2 FIELD QUALITY CONTROL

A. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

END OF SECTION 07 50 00
SECTION 07 55 63 – VEGETATED PROTECTED MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
1. Vegetated protected membrane roofs are permitted only with the approval of the University Project Manager. If approved, the vegetative and growth media layer may be either intensive or extensive.
2. Provide electronic leak detection system at all vegetated protected membrane roofing.
3. Provide concrete substrate only.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Vegetated Protected Membrane Roof System: Multilayer roofing system comprised of a substrate primer, reinforced waterproof roofing membrane, separation/protection course, root barrier, board insulation, air layer, moisture mat, drainage/water retention component, filter fabric, growth media (soil) and vegetation (plant material).

B. Basis-of-Design Product: Subject to compliance with requirements, provide American Hydrotech Garden Roof assembly or a comparable product.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Water Test: Test all roof areas using electronic breach detection equipment after completion of membrane and prior to placement of subsequent overburden.

END OF SECTION 07 55 63
SECTION 07 62 00 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   2. Provide two lines of butyl sealant at all flashing and equipment base lap joints to maintain weatherproof seal.

B. PERFORMANCE REQUIREMENTS
   1. Roof Edge Flashing and Copings: Capable of resisting Wind Zone 3 forces according to FMG Loss Prevention Data Sheet 1-49.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sheet Metals:
   1. Aluminum Sheet with Smooth, Flat Surface:
      a. Coil-Coated Finish: Three-coat fluoropolymer.
      b. Use: For all exposed to view locations.
   2. Stainless-Steel Sheet: 2D (dull, cold rolled) finish with surface.
      a. Use: For all concealed from view locations.

B. Underlayment: Self-adhering, high-temperature sheet.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 62 00
SECTION 07 72 00 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. All roof curbs to be 12 inch minimum above adjacent finished roof membrane surface.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Roof Curbs. Insulated.
   1. Height: Minimum 12 inches.
   4. Integral spring-type vibration isolators.
   5. Security grille where indicated.

B. Equipment Supports: Insulated.
   1. Height: Minimum 12 inches.

C. Roof Hatches: Insulated with double-walled curbs.
   1. Height: Minimum 12 inches.
   5. Accessories: Safety railing system and ladder-assist post.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 72 00
SECTION 07 81 00 - APPLIED FIREPROOFING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Sprayed fire-resistive material (SFRM) to be wet, cementitious type containing no asbestos.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fire-Resistance Design: Tested according to ASTM E 119 or UL 263. Steel members are considered unrestrained.

B. Standard Density SFRM: For interior use unless noted otherwise:
   1. Density: Not less than 15 lb/cu. ft. and as specified in the approved fire-resistance design.
   2. Fungus resistant.

C. Medium Density SFRM: For interior use at all buildings classed as high-rise construction, elevator shafts and mechanical rooms:
   1. Density: Not less than 22 lb/cu. ft. and as specified in the approved fire-resistance design.
   2. Fungus resistant.

D. High Density SFRM: For interior use in high abrasion area and protected exterior use:
   1. Density: Not less than 40 lb/cu. ft. and as specified in the approved fire-resistance design.
   2. Fungus resistant.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 07 81 00
SECTION 07 92 00 - JOINT SEALANTS

PART 1 - GENERAL

1.1 EXTENDED WARRANTY: Provide a written two-year warranty, signed by Contractor and sealant installer, guaranteeing all exterior joints and interior joints detailed within the Vivarium to be water and air tight for a period of not less than two (2) years from date of the Letter of Acceptance of the Work by the University.

1. Exception: Provide 20 year warranty period from date of the Letter of Acceptance of the Work by the University for sealants used in BSL3 only.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS

A. Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.
   1. Use: For joints in vertical surfaces.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. Dow Corning Corporation; 790.
      b. GE Advanced Materials - Silicones; SilPruf LM SCS2700.
      c. Tremco Incorporated; Spectrem 1.

B. Single-Component, Pourable, Traffic-Grade, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade P, Class 100/50, for Use T.
   1. Use: For joints in horizontal traffic surfaces.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. Dow Corning Corporation; 890-SL.
      b. Pecora Corporation; 300 SL.
      c. Tremco Incorporated; Spectrem 900 SL.

C. Mildew-Resistant, Single-Component, Acid-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
   1. Use: For joints in restrooms, janitor’s closets, and other areas subject to continued moisture exposure or high humidity, including door frames and all static joints in ABSL and animal facilities.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Building Systems; Omniplus.
      b. Dow Corning Corporation; 786 Mildew Resistant.
      c. GE Advanced Materials - Silicones; Sanitary SCS1700.
      d. Tremco Incorporated; Tremsil 200 Sanitary.

D. Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834, Type OP, Grade NF.
   1. Use: For interior door frames and other static joints.
   2. Products: Subject to compliance with requirements, provide one of the following:
      a. BASF Building Systems; Sonolac.
      c. Pecora Corporation; AC-20+.
      d. Tremco Incorporated; Tremflex 834.

E. Acoustical Joint Sealant: Nonsag, paintable, nonstaining latex.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Pecora Corporation; AC-20 FTR.
      b. USG Corporation; SHEETROCK Acoustical Sealant.
F. Cylindrical Joint-Sealant Backing: ASTM C 1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

PART 3 - EXECUTION

3.1 INSTALLATION

A. SPECIAL INSTALLATION REQUIREMENTS AT VIVARIUM AND CORE LAB: Provide the following for the Vivarium complete and the BSL3 Core Lab. Provide mildew-resistant sealant listed above at all conditions listed below:

1. Ceilings: Fully seal all joints at access panels, light fixtures, electrical devices, mechanical devices, fire protection devices, etc.

2. Walls: Fully seal all joints, including but not limited to, joints between finished wall surface and door and window frames, power boxes, plug mold, wire mold, alarm and sensor boxes, access panels, electrical devices, plumbing devices, mechanical devices, fire protection devices, wall bumper mounting plates, wall plates, wall-mounted equipment, window sills and jambs, etc.

3. Wall and Ceiling Penetrations: Completely seal all penetrations, including but not limited to, joints between finished surface and electrical conduits, electrical plugs and switches, light fixtures, cover plates, piping for water, gas, vacuum, gas, soil and waste lines, mechanical ducts, registers, etc.

4. Sealant is not required at inside corners of wall-to-wall and wall-to-ceiling joints in drywall construction or as a filler in preformed metal control and expansion joints in drywall construction.

END OF SECTION 07 92 00
SECTION 08 00 00 - OPENINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Design doors to be larger than the width of the largest piece of equipment to be installed in the space.
   2. Provide either hollow metal or glazed aluminum storefront for all exterior doors; wood doors not permitted.
   3. Provide either hollow metal or solid-core wood for interior doors.
   4. Provide 3’-0” by 7’-0” doors typical; wider doors are permitted if required by function and approved by the University Project Manager.
   5. Prepare doors and frames to receive security hardware including door switch monitoring devices. Refer to 28 13 00 – Access Control.
   6. All replacement windows must be approved by the University Campus Architect and the University Project Manager.
   7. Provide solid doors for vermin control at all OLAR doors.
   8. All-glass doors are prohibited for interior use. Provide wood stile and rail doors with glass.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Doors:
   1. Provide all fire-rated doors and frames with an approved UL label.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 00 00
SECTION 08 11 13 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. Ceco Door Products; an Assa Abloy Group company.
   2. Curries Company; an Assa Abloy Group company.
   4. Steelcraft; an Ingersoll-Rand company.
   5. Any current member in good standing of the Steel Door Institute (SDI).

2.2 INTERIOR DOORS AND FRAMES

   1. Edge Construction: Model 2, Seamless.
   2. Core: Manufacturer's standard.
   3. Frames: Face welded.

2.3 EXTERIOR DOORS AND FRAMES

   1. Edge Construction: Model 2, Seamless.
   2. Core: Manufacturer's standard, insulated.
   3. Frames: Face welded.

2.4 FABRICATION

A. Preparation for Finish Hardware:
   1. Doors and Frames: Spot weld all reinforcement at the factory. Drill and tap for mortise template hardware.
   2. Frame Reinforcement: Comply with ANSI/SDI A250.6 and the following:
      a. Hinges: 7 gage plate, 12 inches long by full width of jamb at each hinge.
      b. Lock: 12 gage.
      c. Strikes, Flush Bolts, and all other Surface Mounted Hardware: 12 gage.
      d. Closer: 10 gage channel section, 12 inches long and full width of frame trim.
   3. Door Reinforcement: Comply with ANSI/SDI A250.6 and the following:
      a. Hinges: 7 gage, 9 inch long, welded to 16 gage interior edge channels at each hinge.
      b. Closers: 12 gage box section minimum 4 inch deep and 12 inch long.
      c. Locksets, Deadbolts, Panic Devices: 12 gage.
      d. Pull Plates, Flush Bolts, and Surface Mounted Hardware: 12 gage.

B. Frame Anchors:
   1. Frames up to 7 feet tall: 3 anchors per jamb.
   2. Frames greater than 7 feet and less than 8 feet tall: 4 anchors per jamb.
   3. Frames greater than 8 feet tall: 1 additional anchor for each 2 feet or fraction thereof in height per jamb.
PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 11 13
SECTION 08 14 16 - FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide solid-core doors only; hollow-core not permitted.
   2. Flush wood doors permitted for interior use only; exterior wood doors are not permitted.
   3. In new construction use close-grained wood veneer; in existing buildings match existing doors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. Algoma Hardwoods, Inc.
   2. Eggers Industries.

2.2 MATERIALS, GENERAL

2.3 DOOR CONSTRUCTION, GENERAL

A. Quality Standard: WDMA I.S.1-A.

B. WDMA I.S.1-A Performance Grade:
   1. Heavy Duty unless otherwise indicated.
   2. Extra Heavy Duty: Classrooms, public toilets, janitor's closets, assembly spaces, and exits.

2.4 VENEER-FACED DOORS FOR TRANSPARENT FINISH

A. Interior Solid-Core Doors:
   1. Grade: Premium, with Grade A faces.
   2. Species: Close-grained.
   3. Cut: Plain sliced (flat sliced) or quarter sliced.
   4. Assembly of Veneer Leaves on Door Faces: Center-balance match.
   5. Core: Particleboard.
   6. Rails and Stiles: LSL, adhered to core.
   7. Construction: Five or seven plies, bonded.

2.5 DOORS FOR OPAQUE FINISH

A. Interior Solid-Core Doors:
   1. Grade: Premium.
   2. Faces: Medium-density overlay.
   3. Core: Particleboard.
   4. Construction: Five or seven plies, bonded.
2.6 PRIMING/FINISHING

A. Shop Priming:
   1. Doors for Opaque Finish: One coat of wood primer.

B. Factory Finishing: Doors indicated to receive transparent finish.

C. Transparent Factory Finishes:
   1. Grade: Premium.
   2. Finish: Catalyzed polyurethane.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Seal top, bottom, and edges of doors immediately after fitting.

B. Through-bolt (barrel bolts) door closers and exit devices.

END OF SECTION 08 14 16
SECTION 08 30 00 - SPECIALTY DOORS AND FRAMES

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide insulating doors between exterior and interior conditioned space.
   2. Where sectional doors are required, provide aluminum sectional doors for glazed doors and insulated, galvanized steel sectional doors for opaque doors.
   3. Provide loading dock door operators with remote-control station equipped with momentary-contact, three push-button controls labeled “Open,” “Close,” and “Stop.” Do not provide key operation.

B. Performance Requirements:
   1. Basic Wind Speed, Exterior Doors: Project Specific. Operability under wind load is required.

PART 2 - PRODUCTS

2.1 OVERHEAD COILING DOORS

A. Coiling Service Door
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, 610 Series Service Door or a comparable product by one of the following:
      a. Cookson Company.
      b. Cornell Iron Works, Inc.
      c. Wayne-Dalton Corp.
   2. Service Door: Door curtain of interlocking metal slats, designed to withstand wind loading.
      a. Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural steel sheet; nominal sheet thickness (coated) of minimum 0.040 inch (20 gauge) and as required to meet requirements.
   4. Electric Door Operator: Standard duty, up to 60 cycles per hour.
      a. Obstruction-detection device.
      b. Remote-control station.
   5. Door Finish: Baked-enamel or powder-coated.

B. Insulated Coiling Service Door
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, 625 Series Insulated Service Door or a comparable product by one of the following:
      a. Cookson Company.
      b. Cornell Iron Works, Inc.
      c. Wayne-Dalton Corp.
   2. Insulated Service Door: Door curtain of galvanized steel.
      a. Insulated Steel Door Curtain Slats: Zinc-coated (galvanized), cold-rolled structural steel sheet; nominal face sheet thickness of minimum 0.034 inch (22 gauge) and back sheet thickness of 0.028 inch (24 gauge); fill slat cavity with CFC-free, foamed-in-place, polyurethane insulation.
   4. Electric Door Operator: Standard duty, up to 60 cycles per hour.
      a. Obstruction-detection device.
      b. Remote-control station.
5. Door Finish: Baked-enamel or powder-coated.

C. **Fire-Rated Counter Door**
1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, 640 Series Overhead Coiling Counter Fire Door or a comparable product by one of the following:
   a. Cookson Company.
   b. Cornell Iron Works, Inc.
   c. Wayne-Dalton Corp.
2. Fire-Rated Counter Door: Door curtain of minimum 0.034 in (22 gauge) galvanized steel.
   a. Locking Device Assembly: Cremone type, both jamb sides locking bars, operable from inside and outside with mortise lock capable of accepting a small format (7-pin) interchangeable core.

2.2 **OVERHEAD COILING GRILLES**

A. **Open-Curtain Security Grille Assembly**
1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, 670 Series Upcoiling Security Grille, or comparable product by one of the following:
   a. Cookson Company.
   b. Cornell Iron Works, Inc.
2. Overhead Coiling Grille: Curtain having a network of horizontal rods that interconnect with vertical links.
3. Hood: Aluminum.
4. Electric Grille Operator: Standard duty, up to 60 cycles per hour.
   a. Obstruction-detection device.
   b. Cylinder lock for electric operation with interlock switch; capable of accepting a small format (7-pin) interchangeable core.
5. Aluminum Finish: Clear anodized.

2.3 **SECTIONAL DOORS**

A. **Steel Door Assembly**
1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, Series 418 Insulated Steel Sectional Door or a comparable product by one of the following:
   a. Raynor.
   b. Wayne-Dalton Corp.
2. Steel Sections: Zinc-coated (galvanized) steel sheet with minimum G60 zinc coating; G90 preferred.
   a. Section Thickness: 2 inches.
   b. Exterior-Face, Steel Sheet Thickness: 0.064-inch- (16 gauge) nominal coated thickness.
   c. Insulation: Foamed in place, expanded polystyrene.
   d. Interior Facing Material: Zinc-coated (galvanized) steel sheet of 0.022-inch- (26 gauge) nominal coated thickness.
3. Foamed-in-Place Thermal Insulation: Insulate interior of steel sections with door manufacturer's standard CFC-free polystyrene insulation, foamed in place to completely fill interior of section and pressure bonded to face sheets to prevent delamination under wind load.
4. Weatherseals.
5. Electric Door Operator: Standard duty, up to 60 cycles per hour.
   a. Obstruction-detection device.
   b. Remote operation station with open, close and stop controls; if keyed must accept small format (7-pin) interchangeable core.

B. Aluminum Door Assembly
1. Basis-of-Design Product: Subject to compliance with requirements, provide Overhead Door Corporation, Series 521 Aluminum Sectional Overhead Door or a comparable product by one of the following:
   a. Raynor.
   b. Wayne-Dalton Corp.
2. Aluminum Sections: Full vision, fabricated from 1-3/4 inch-thick, 6063-T6 aluminum sections glazed with 1/2 inch thick clear insulating glass.
3. Weatherseals.
4. Electric Door Operator: Standard duty, up to 60 cycles per hour.
   a. Obstruction-detection device.
   b. Remote operation station with open, close and stop controls; if keyed must accept small format (7-pin) interchangeable core.
5. Door Finish: Baked-enamel or powder-coat finish, AAMA 2603.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 30 00
PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
1. Curtain wall framing systems preferred, storefront glazing systems acceptable only for ground floor glazing not greater than 10 feet in height and for punched or ribbons windows located not greater than 60 feet above grade. All storefront glazing systems must be provided with extruded sills and end dams.
2. All aluminum-framed storefront glazing members shall be thermally-broken.
3. Narrow and medium stile doors are not permitted.
4. Sliding entrance doors are not permitted.

B. Performance Requirements:
1. Delegated Design: Contractor to design aluminum-framed systems.
2. Structural Performance:
   a. Wind Loads: Project specific.
3. Deflection of Framing Members:
   a. Deflection Normal to Wall Plane: Limited to L/175.
   b. Deflection Parallel to Glazing Plane: Limited to L/360 or 1/8 inch, whichever is smaller.
4. Air Infiltration: 0.06 cfm/sq. ft. when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft.
5. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.
6. Water Penetration under Dynamic Pressure: No water penetration when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.
7. Condensation Resistance: No condensation shall form on interior surfaces of aluminum glazing at exterior and interior winter design temperature and relative humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer TrifabVG-451T or comparable products by one of the following:
1. EFCO Corporation.
2. Oldcastle BuildingEnvelope.
3. United States Aluminum.
4. YKK AP America Inc.

2.2 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer.

B. Steel reinforcement as required for loads.

2.3 FRAMING SYSTEMS

A. Framing Members: Manufacturer's standard extruded-aluminum framing members.
2. Glazing System: Retained mechanically with gaskets on four sides.
4. Nominal Size: 2-inch-wide by 4-1/2-inch-deep.

2.4 ENTRANCE DOOR SYSTEMS

A. Entrance Doors:
2. Door Design: Wide stile.
   a. Stiles must be wide enough to accommodate rim type metal exit hardware.

B. Entrance Door Hardware:
1. Butt hinges; pivots not permitted on new installations.
2. Closers: surface mounted.
3. Reinforce doors to accept magnetic locking hardware, door position switches and request-to-exit devices for control by security system.
4. Locks: Where provided cylinders must accept small format (7-pin) interchangeable cores.

2.5 ALUMINUM FINISHES

A. Aluminum Finishes: High-performance organic (three coats).

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 41 13
SECTION 08 44 00 - CURTAIN WALL AND GLAZED ASSEMBLIES

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide conventionally glazed and/or structural-sealant-glazed aluminum curtain wall assemblies installed as stick or unitized assemblies. Unitized preferred; stick acceptable.
   2. All curtain wall members shall be thermally-broken.
   3. Narrow and medium stile doors are not permitted.
   4. Sliding entrance doors are not permitted.

B. Performance Requirements:
   1. Delegated Design: Contractor to design aluminum curtain wall systems.
   2. Structural Performance:
      a. Wind Loads: Project specific.
   3. Deflection of Framing Members:
      a. Deflection Normal to Wall Plane: Limited to L/175.
      b. Deflection Parallel to Glazing Plane: Limited to L/360 or 1/8 inch, whichever is smaller.
   4. Air Infiltration: 0.06 cfm/sq. ft. when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft.
   5. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.
   6. Water Penetration under Dynamic Pressure: No water penetration when tested according to AAMA 501.1 under dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft.
   7. Energy Performance: Glazed aluminum curtain walls shall have minimum energy performance ratings per NFRC as follows:
      a. Thermal Transmittance (U-factor): 0.45 Btu/sq. ft. x h x deg F.
      b. Solar Heat Gain Coefficient: 0.40.
   8. Condensation Resistance: No condensation shall form on interior surfaces of aluminum glazing at exterior and interior winter design temperature and relative humidity.

PART 2 - PRODUCTS

2.1 FRAMING

A. Framing Members: Extruded or formed aluminum.
   2. Glazing System: One or more of the following:
      a. Retained mechanically with gaskets on four sides.
      b. Two-sided structural-sealant-glazed and mechanically retained with gaskets on two sides.
      c. Factory-glazed, four-sided structural-sealant-glazed.

2.2 ALUMINUM FINISHES

A. Aluminum Finishes: High-performance organic (three coats).

2.3 FABRICATION

A. Provisions for field replacement of glazing.
PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Testing: By The University-engaged agency.

B. Testing Services:
   5. Frequency of Testing: To be determined by Design Professional.

END OF SECTION 08 44 13
SECTION 08 51 13 - ALUMINUM WINDOWS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide aluminum metal windows; wood and steel windows not permitted.
   2. Operable windows are prohibited.
   3. Provide aluminum windows capable of being re-glazed from either inside or outside.

B. Performance Requirements:
      a. Minimum Performance Class: AW.
      b. Minimum Performance Grade: 100.
   2. Air Infiltration: 0.1 cfm/sq. ft. when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft.
   3. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at a minimum static-air-pressure difference of 15 lbf/sq. ft.
   4. Thermal Transmittance: 0.58 Btu/sq. ft. x h x deg F maximum based on use of 1 inch clear insulating glass.
   5. Condensation Resistance: No condensation shall form on interior surfaces of aluminum glazing at exterior and interior winter design temperature and relative humidity.

PART 2 - PRODUCTS

2.1 ALUMINUM WINDOWS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kawneer Isolock Window Model 8225TL or comparable product from one of the following:
   1. EFCO Corporation.
   2. Wausau Window and Wall Systems.

B. Frames and Sashes: Thermally improved aluminum extrusions.


PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 51 13
SECTION 08 71 00 - DOOR HARDWARE

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements

1. Provide Mortise and Rim Cylinders capable of accepting small format (7 pin) interchangeable cores.
   a. Dull chromium (626) finish, unless otherwise specified and approved by the University Locksmith through the University Project Manager.

2. Consult with the University Locksmith, through the University Project Manager, regarding the various lock functions and keyway for each building.

3. Provide dull chromium (626) finish durable door stops, holders, flush bolts, etc.

4. Provide backing behind doorstops.

5. Provide quality weather stripping on all exterior doors.

6. Computer operated proximity card access systems are allowed. Coordinate design with the University Project Manager.

7. Provide electric strikes or electric locks where required. Use of electrified hinges must be approved by the University Project Manager. Refer to 28 13 00 – Access Control for additional information.

8. Provide manual lock-down capability via locking doors or manual key override to electronic lock systems at all buildings. Egress doors must maintain all required egress characteristics.

9. Concealed rods are not permitted.

10. Coordinate door hardware with security hardware requirements. Refer to Division 28 for additional information.

11. Coordinate all hardware and access control at the University of Colorado Denver with the University Locksmith.

B. Performance Requirements

1. Key interchangeable cores at factory.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Lock Sets:
   a. University of Colorado Anschutz Medical Campus:
      1) Best 9K Series Heavy-Duty Lockset with 14D Lever Style Cylindrical Lever sets.
   b. University of Colorado Denver:
      1) Schlage Falcon T Series with quantum lever 626 satin chrome finish and Schlage interchangeable everest B core

2. Automatic Door Opener:
   a. Stanley Magic Door, Magic Swing Micro (preferred)
   b. Dorma ED800

3. Closers:
   a. LCN 4041
   b. Norton 1600 Series at storefront applications
   c. LCN Door Closer, 1460 Series Aluminum

4. Hinges:
   a. Hager
   b. Stanley – FBB179
   c. Stanley – FBB168

5. Exit Device:
a. Von Duprin (preferred)

6. Key Lock Box:
   a. Knox Company, 3200 Series

2.2 MATERIALS

A. Lock Sets:
   1. Lock Functions: Selected by the University locksmith through the University Project Manager. Stock numbers provided by the University Locksmith from acceptable manufactures.

B. Door Guards:

C. Key Lock Box
   1. Recessed, heavy-duty, high-security key box with hinged door. No tamper alarm.
   2. Color: As determined by design team.
   3. Coordinate location with the University Fire and Life Safety Officer.
   4. Mounting Height: 5 feet above finished surface.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 71 00
SECTION 08 80 00 - GLAZING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. At a minimum provide high-performance, low-e, heat-strengthened, insulating-glass units at all exterior glazed openings.
      a. Basis-of-Design Exterior Glazing: Viracon, VE1-2M.
   2. At all exterior glazed openings, provide glazing with low reflectivity.
   3. Select and configure glazing to support daylighting wherever possible and appropriate.

B. PERFORMANCE REQUIREMENTS
   1. Engineering design of glass by Contractor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Glass Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. AFG Industries, Inc.
   2. Guardian Glass.
   4. PPG Industries.
   5. Viracon.

B. Fire-Protection-Rated Glazing Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. InterEdge, Inc., a subsidiary of AFG Industries, Inc.
   4. Safi First; SuperLite C/P.
   5. Schott North America, Inc.

2.2 MONOLITHIC-GLASS TYPES

A. Clear float glass: Use at all interior door and window locations not required to be safety glass or fire-protection-rated.

B. Clear fully tempered float glass at all interior door and window locations where safety glass is required.

C. Polished wired glass permitted where fire-protection-rated glass is required.

2.3 INSULATING-GLASS TYPES

A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190. Use at all exterior glazed openings.
2.4 FIRE-PROTECTION-RATED GLAZING TYPES

A. Fire-Protection-Rated Glazing: Listed and labeled by a testing agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252 for door assemblies and NFPA 257 for window assemblies. Permitted in lieu of polished wired glass where fire-protection-rated glass is required.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 08 80 00
SECTION 09 00 00 - FINISHES

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Interior design color palette proposed by the Design Professional must meet all criteria established with input and approval by the University Campus Architect through the University Project Manager.
   2. Provide rubber base at both carpet and resilient flooring installations. Upgrades are permissible with approval of the University Campus Architect through the University Denver Project Manager.
   3. All penetrations and/or seams in materials in BSL3, Vivaria, and other similar functional areas are to be sealed, unless otherwise noted.

B. Performance Requirements:
   1. Fire-Test-Response Characteristics:
      a. Surface-Burning Characteristics: As determined by testing per ASTM E 84.
         1) Flame-Spread Index: 25 or less.
         2) Smoke-Developed Index: 25 or less.
         3) Fuel Contributed Index: 15 or less.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION OF CONCRETE TO RECEIVE MOISTURE SENSITIVE FLOORING

A. Prepare all concrete substrates to receive moisture sensitive floor finishes including, but not limited to, resilient sheet floor, linoleum flooring, resilient tile flooring, resinous matrix terrazzo flooring, resinous flooring, sheet carpeting and tile carpeting, according to ASTM F 710 and the following:
   1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
   2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
   3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrate pH is between 7.0 and 9.0.
   4. Moisture Testing: Perform tests recommended by manufacturer and as follows. Proceed with installation only after substrates pass testing.
      a. Perform anhydrous calcium chloride test, ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
      b. Perform relative humidity test using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 80 percent relative humidity level measurement.

B. Provide moisture vapor emissions and alkalinity control system to all concrete substrates that fail alkalinity and/or moisture testing.

END OF SECTION 09 00 00
SECTION 09 22 16 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Space studs at 16 inches on center maximum.
   2. Where interior partitions do not extend to the underside of structure, extend partition 6” above the ceiling grid and brace to structure at 4 feet on center.

B. Performance Requirements:
   1. Partitions, General: Provide metal framing systems of base-metal thickness and spacing capable of limiting lateral deflections when subjected to a 5 psf uniform lateral load to the following:
      a. L/240 where supporting gypsum board only.
      b. L/360 where supporting plaster or ceramic tile finishes.
      c. L/720 where providing backup to stone or masonry.
   2. Partitions Enclosing Pressurized Mechanical Rooms: Provide metal framing systems of base-metal thickness and spacing capable of limiting lateral deflections to L/240 when subjected to a 15 psf uniform lateral load or the design value induced by the mechanical system, whichever is greater.
   3. Suspended Ceiling Design Requirements: Provide metal framing systems of base-metal thickness and spacing capable of limiting ceiling deflections to L/360 when subjected to a minimum 4 psf uniform load or the actual weight of ceiling hung materials, whichever is greater.
   4. Engineering design of non-structural metal framing by Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Framing for Framed Assemblies:
   1. Steel studs and runners: 0.033-inch-thick (20 gauge) minimum.
   2. Dimpled steel studs and runners: 0.025-inch-thick minimum, with structural properties equivalent to 0.0329-inch-thick steel studs.

PART 3 - EXECUTION (Not Applicable)

3.1 INSTALLATION

A. Secure with fasteners or proper crimping tools; do not weld.

END OF SECTION 09 22 16
SECTION 09 29 00 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
   1. Design all walls within a vivarium to have a sound transmission class (STC) rating of 55 or better.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Interior Gypsum Board:
   1. Gypsum board, Type X: Provide 5/8 inch thick, typical unless noted otherwise.
   2. Abuse-resistant gypsum board: Provide at service corridors.
   3. Moisture- and mold-resistant gypsum board: Provide at all high humidity areas.

B. Exterior Gypsum Board for Ceilings and Soffits:

C. Tile-Backing Panels:
   1. Glass-mat, water-resistant backing board.

D. Trim Accessories:
   2. Exterior: Hot-dipped galvanized steel sheet or rolled zinc.

E. Auxiliary Materials
   1. Sound attenuation blankets.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Finishing Gypsum Board Assemblies:
   1. Levels of Gypsum Board Finish: At a minimum, comply with recommendations in GA-214, “Recommended Levels of Gypsum Board Finish.”

END OF SECTION 09 29 00
SECTION 09 30 00 - TILING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide tile selection as approved by the University Campus Architect through the University Project Manager.
   2. Provide waterproof membrane under all tile installations above occupied space.

PART 2 - PRODUCTS

2.1 TILE PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Olean; Division of Dal-Tile International Inc.
   2. Daltile; Division of Dal-Tile International Inc.
   3. United States Ceramic Tile; a Roca Tile Group company.

B. Floor Tile: Unglazed ceramic mosaic tile.
   1. Size: 2 by 2 inches, factory mounted onto sheets with mesh, dot, net or other backing method.

C. Wall Tile: Glazed wall tile.
   1. Size: 4-1/4 by 4-1/4 inches, cushion edge.

D. Other Tile: Only as approved by the University Campus Architect through the University Project Manager.

E. Trim Shapes:
   1. Wainscot cap: Surface bullnose.
   2. Base: Coved base.
   3. Outside Corners: Surface bullnose.
   4. Inside Corners:
   5. Jambs: Surface bullnose where tile projects from jamb.

2.2 ACCESSORY MATERIALS

A. Thresholds: Stone.

B. Waterproof Membrane: Chlorinated polyethylene sheet; fluid applied membranes are not permitted.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide The Noble Company, NobleSeal TS or comparable product.

C. Crack Isolation Membrane: Chlorinated polyethylene sheet.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide The Noble Company, NobleSeal CIS or comparable product.

D. Metal base and edge strips: Where tile trim shapes are not available use metal accessories:
   1. Coved Metal Base: Subject to compliance with requirements, provide Schluter-DILEX-EHK or comparable product.
   2. Coved Metal Inside Corner: Subject to compliance with requirements, provide Schluter-DILEX-EHK or comparable product.
3. Edge Protection: Subject to compliance with requirements, provide Schluter-SCHIENE or comparable product.

4. Outside Corner: Subject to compliance with requirements, provide Schluter-QUADEC or comparable product.

5. Wainscot Cap: Subject to compliance with requirements, provide Schluter-JOLLY, Schluter-QUADEC or comparable product.

6. Transition Strips: As required where adjacent floor finish is of different thickness.

PART 3 - EXECUTION

3.1 INTERIOR TILE INSTALLATION SCHEDULE

A. Interior Floors on Concrete:
   1. TCNA F113: Thin-set mortar.
      b. Grout: Polymer-modified.
   2. TCNA F122: Thin-set mortar on waterproof membrane.
      b. Grout: Polymer-modified.
   3. TCNA F125A: Thin-set mortar on crack isolation membrane.
      b. Grout: Polymer-modified.

B. Interior Walls, Masonry or Concrete:
   1. TCNA W202: Thin-set mortar.
      b. Grout: Polymer-modified.

C. Interior Walls, Metal Studs or Furring:
   1. TCNA W245: Thin-set mortar on coated glass-mat, water-resistant gypsum backer board.
      b. Grout: Polymer-modified.

D. Shower Receptor and Walls, Concrete or Masonry:
   1. TCNA B421: Thin-set mortar on waterproof membrane.
      b. Grout: Polymer-modified.

E. Shower Receptor and Walls, Metal Studs or Furring:
   1. TCNA B420: Thin-set mortar on coated glass-mat, water-resistant backer board.
      b. Grout: Polymer-modified.

END OF SECTION 09 30 00
SECTION 09 51 13 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirement:
   1. Provide patterns, colors and finishes approved by the University Campus Architect through the University Project Manager.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acoustical Ceiling Panels: Fire-resistance rated where required; ASTM E 1264.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong World Industries, Inc.
      b. CertainTeed Corp.
      c. USG Interiors, Inc.
   2. Type and Form for typical installations: Type III, Form 1, nodular; sag resistant with anti-microbial treatment.
   3. Type and Form for Laboratories: Type IV, mineral base with membrane overlay; Form 2, water felted; with fiberglass-fabric face; sag resistant with anti-microbial treatment.
   5. LR: Approximately 0.90.
   6. NRC: Approximately 0.70.
   7. CAC: Approximately 35.
   8. Thickness: 3/4 inch.
   9. Modular Size: 24 by 24 inches or 24 by 48 inches scored to look like 24 by 24 inches.

B. Metal Suspension Systems: ASTM C 635.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong World Industries, Inc.
      b. CertainTeed Corp.
      c. Chicago Metallic Corporation.
      d. USG Interiors, Inc.
   2. Wire hangers, braces, and ties.

C. Metal Edge Moldings and Trim: Roll-formed sheet metal.

D. Ceiling Panel Plenum Access, Identification Markings:
   1. Removable ceiling tiles may provide access to mechanical and electrical components located above the ceiling. Where required, mark ceiling panel with colored map tacks glued in place according to the following:
      a. Waste Valves and Unions: Blue.
      b. Waste Cleanouts: Black.
      c. Ventilation Test Areas and Dampers: Purple.
      d. Fire Dampers or Fire Detectors: Red.
      e. Electrical transformers or resistance heaters: Orange.
f. Natural Gas, Oxygen, and Steam Valves or Unions: Yellow.
g. Nitrogen, Compress Air, and Vacuum Valves or Unions: Green.
h. Miscellaneous Mechanical Items: Gray.

PART 3 - EXECUTION

3.1 INSTALLATION


END OF SECTION 09 51 13
SECTION 09 61 19 - VAPOR EMISSION AND ALKALINITY CONTROL FLOORING TREATMENT

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
   1. Test all concrete substrates scheduled to receive moisture sensitive flooring.
   2. Provide vapor emission and alkalinity control flooring treatment at all concrete substrates which fail testing criteria indicated in Section 09 00 00 “Finishes” of this guideline.
   3. In Section 01 21 00 “Allowances” specify a quantity allowance for the provision of vapor emission and alkalinity control flooring treatment equal to 35 percent of all concrete substrates scheduled to receive moisture sensitive flooring.
   4. In Section 01 20 00 “Unit Prices” require that Contractor provide a unit price bid on a per square foot basis for the provision of the specified vapor emission and alkalinity control flooring treatment including floor preparation and installation complete.

PART 2 - PRODUCTS

2.1 MOISTURE-RESISTANT FLOORING TREATMENT

A. Products: Subject to compliance with requirements, provide one of the following:
   1. Ardex Engineered Cements; ARDEX MC, Moisture Control System.
   2. Floor Seal Technology, Inc.; Moisture Reduction System, MES 100.

B. System Description:
   1. Two component resinous treatment system, VOC compliant, low viscosity and elastomeric properties to expand and contract with limited slab movement. Formulated to saturate concrete surfaces and mechanically restrict moisture and alkalinity levels.

C. System Physical Properties: Provide resinous flooring treatment with the following minimum physical properties when tested according to test methods indicated:
   1. Water Vapor Transmission: Varies, 94% reduction per ASTM E 96.
   2. Alkalinity Resistance: Passes up to a pH of 14 per ASTM D 1308.
   3. Adhesion Strength: 500 psi minimum per ASTM D 4541.
   4. Relative Humidity Resistance: 100% per ASTM F 2170.
   5. VOC: Less than 100 g/L per SCAQMD Rule #1113.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Scarify slab surface in area of application by shot blasting or other method acceptable to coating treatment manufacturer.

B. Apply coating in strict compliance with manufacturer’s installation instructions.

END OF SECTION 09 61 19
SECTION 09 65 00 - RESILIENT FLOORING

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 RESILIENT BASE AND ACCESSORIES

A. Resilient Base:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Johnsonite.
      b. Musson, R.C. Rubber Co.
      c. Roppe Corporation, USA.
   3. Style: Cove at all locations.
   4. Minimum Thickness: 0.125 inch.
   5. Height: 4 inches.

B. Resilient Molding Accessory: Rubber.
   1. Edge Strips: 0.125 inch thick, 1 inch wide, with tapered or bullnose edge.

C. Abrasive Strips: Self-adhesive, 1 inch wide, with aluminum oxide grit.

2.2 RESILIENT TILE

A. Vinyl Composition Floor Tile:
   1. Class: Through pattern.
   2. Wearing Surface: Smooth.
   3. Thickness: 0.125 inch.
   4. Size: 12 by 12 inches.

2.3 RESILIENT SHEET FLOORING

A. Vinyl Sheet Floor Covering: ASTM F 1303, Type I, Grade 1, with Class B backing.
   1. Thickness: 0.080 inch thick.
   2. Wearing Surface: Smooth.
   3. Sheet Width: As standard with manufacturer.
   4. Seaming Method: Heat welded at medical labs (BSL2); standard otherwise.

B. Linoleum Floor Coverings:
   1. Sheet Flooring: In manufacturer's standard length by not less than 78 inches wide.
   2. Seaming Method: Heat welded at medical labs (BSL2); standard otherwise.
   3. Thickness: 0.08 inch.

2.4 INSTALLATION MATERIALS

1. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based provided or approved by manufacturer for applications indicated and capable of taper to feather edge.
2. Adhesives: Water-resistant type recommended by manufacturer to suit resilient products and substrate conditions indicated.
3. Floor Polish: Provide stripper, sealer and polish recommended by the University Environmental Health and Safety (EHS) through the University Project Manager.

PART 3 - EXECUTION

3.1 CLEANING AND PROTECTION

A. Floor Polish: Strip factory seal and apply finish recommended by the University EHS through the University Project Manager.

END OF SECTION 09 65 00
SECTION 09 67 23 - RESINOUS FLOORING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
1. Provide towed-on, skid-resistant, antimicrobial, chemically resistant epoxy flooring at vivariums and other similar functional areas.
2. Provide continuous, seamless, sealed flooring with minimum 4 inch high coved wall base.

PART 2 - PRODUCTS

2.1 RESINOUS FLOORING

A. High-Performance Resinous Flooring and Integral Cove Base:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Stonhard; Stonclad GS with GS4 topcoat or a comparable product.
2. System Characteristics:
   a. Wearing Surface: Textured for slip resistance.
   b. Overall System Thickness: 1/4 inch.
3. System Components:
   a. Body Coat(s):
      1) Resin: Epoxy.
      2) Formulation Description: 100 percent solids.
      3) Application Method: Troweled or screeded.
   b. Topcoat: Sealing or finish coats.
      1) Resin: Epoxy.
      2) Formulation Description: 100 percent solids.
      3) Type: Clear.
      4) Finish: Gloss.
      5) Number of Coats: One.
4. System Chemical Resistance: Coordinate with the University Project Manager for a list of reagents likely to contact resinous flooring during in-service use.

B. Accessories:
1. Primer.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 09 67 23
SECTION 09 68 13 - TILE CARPETING

PART 1 - GENERAL

1.1 SUBMITTALS

A. Review shop drawings for pattern match, if any, for matching during installation and possible waste factors in ordering required amounts. Provide copy of approved shop drawings on job site during installation.

B. Verification Samples: Submit two full size samples illustrating color and pattern for each carpet material specified.

C. Manufacturer’s Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications
   1. Upon request, provide a representative to assist in project start-up and to inspect installation while in process and upon completion.
      a. Representative will notify designated contact if any installation instructions are not followed.
      b. Representative will be present at 6 month and 11 month punch walks.
   2. 5-year documented experience in manufacturing of carpet tile.

B. Installer Qualifications
   1. Flooring contractor must be certified by the carpet manufacturer prior to bid.
   2. Flooring contractor to be a specialty contractor normally engaged in this type of work and has prior experience in the installation of carpet tiles.
   3. Flooring contractor will be responsible for proper product installation, including floor testing and preparation, as specified by the carpet manufacturer and job conditions herein.

C. Single Source Responsibility: Obtain each type of carpet from one source and by a single manufacturer.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in manufacturer’s original packaging listing manufacturer’s name, product name, identification number, and related information.

B. Store in a dry location, between 60 degrees F and 80 degrees F and a relative humidity below 65%. Protect from damage and soiling. Stack carpet in boxes.

C. Make stored materials available for inspection by The University’s representative.

D. Store materials in area of installation for minimum period of 48 hours prior to installation.

1.4 PROJECT CONDITIONS

A. Sub-floor preparation is to include all required work to prepare the existing floor for installation of the product as specified in this document and Manufacturer’s installation instructions.

B. Comply with 09 00 00 – Finishes, Part 3.1 for preparation of concrete to receive moisture sensitive flooring.
C. Provide all material used in sub-floor preparation and repair as recommended by the carpet manufacturer and chemically and physically compatible with the carpet system being bid.

D. Maintain minimum 65 degrees F ambient temperature and 65% Relative Humidity for 72 hours prior to, during, and 48 hours after installation.

E. Do not install carpet until space is enclosed and weatherproof, wet-work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

F. Extra Materials: Refer to Section 01 78 46 – Extra Stock Materials.

1.5 WARRANTY

A. Warranty to be sole source responsibility of the Manufacturer. Second source warranties and warranties that involve parties other than the carpet manufacturer are unacceptable.

B. If the product fails to perform as warranted when properly installed and maintained, repair or replace the affected area at the discretion of the Manufacturer.

C. Chair Pads are not required for carpet warranty coverage.

D. Include carpet product installed on stairs in warranty provided it is properly installed and maintained.

E. Provide warranty for a specifically defined non-prorated period of 15 years to cover the following. “Lifetime” warranties are not acceptable.
   1. Excessive Surface Wear: More than 10% loss of pile fiber weight
   2. Excessive Static Electricity: More than 3.5 kV per AATCC 134; 3.0 kV in areas of heavy electronic usage
   3. No Delamination
   4. No Edge Ravel
   5. No Zippering

F. Provide an additional warranty for a minimum non-prorated period of two years and cover against shrinkage, cupping, and doming.

G. Tuft Bind warranty in lieu of edge ravel and zippering is not acceptable.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. CARPET
   1. Nylon Fiber: Fiber must be premium branded nylon. Mill extruded nylon will not be accepted. 100% type 6,6 bulk continuous filament (BCF) nylon. Hollow filament fiber shape for optimal soil hiding capability. A modification ratio of less than 1.5. Polymer identification to AATCC TM 20.
   2. Construction: Texture - level loop or textured loop with maximum pile height variation of 1/32 inch.
   4. Pile Density: Minimum 5500 for heavy or severe traffic.
   5. Dye Method: Fiber to be minimum 75% solution dyed; 95% preferred.
   6. Stain Resistance: AATCC TM 171 (HWE) for 2 cleanings to simulate removal of topical treatments by hot water extraction, followed by AATCC TM 175 Stain Resistance test; minimum rating of 8 using AATCC Red 40 Stain Scale.
   7. Soil Resistance: Soil resistance treatment to be heat cured by mill during manufacturing process.
8. Coloration/Patterning: Minimum five (5) color hues. Recommended: Hue values to be in medium to medium-dark range with random or complex patterning for optimum soil hiding capability. Restrict solid color carpet to accent areas. Do not use light colors.

2.2 BACKING CHARACTERISTICS
1. Primary Backing: Synthetic Woven or Non-Woven.
2. Pre-Coat (Fusion Coat): Sealant Vinyl
3. Secondary Backing: Vinyl Closed Cell. 100% reclaimed-content, nylon reinforced vinyl matrix backing is preferred and should be provided if available.
   a. High performance, moisture impermeable modular, vinyl
   b. 24” x 24”, or 60cm, or 36” x 36”

2.3 PERFORMANCE CHARACTERISTICS
A. Test reports for the following performance assurance testing to be submitted upon request. Submitted results shall represent average results for production goods of the referenced style.
B. Requirements listed below must be met by all products.
   1. Flooring Radiant Panel; ASTM E-648 / NFPA 253: Class 1 (CRF: 0.45 watts/sq cm or greater)
   2. Federal Flammability : CPSC FF 1-70: Passes (must pass Methenamine Pill test, ASTM D2859 test method)
   3. Smoke Density: ASTM E-662 / NFPA 258; < 450 Flaming Mode (or to State Code)
   4. Electrostatic Propensity: AATCC TM 134 (Step & Scuff): 3.5 kV or less by permanent means (i.e. antistatic filaments) and without chemical treatment. 3.0 kV in areas of heavy electronic usage
   5. Static Coefficient of Friction: ASTM C-1028: Passes ADA Requirements for Accessible Routes (minimum 0.60)
   7. Dimensional stability: Aachen method/ ISO 2551. Maximum change +/-0.20%
   9. Colorfastness to Light: AATCC TM 16.3 to 200 AFU; minimum rating 3-4 using AATCC Grey Scale for color change.
   10. Colorfastness to atmospheric contaminants: AATCC TM 164 (resistance to fade from oxides of nitrogen) and AATCC TM 129 (resistance to fade from ozone) for 2 cycles; minimum rating of 3-4 using AATCC Grey Scale for Color Change.
   11. Colorfastness to crocking: AATCC TM 165, minimum rating of 4 using the AATCC Chromatic Transference Scale. Texture Retention: Vettermann Drum: ASTM D-5417: Minimum 3.5 @ 22,000 cycles or Hexapod Test Method, ASTM D5252, for 12,000 cycles (8.4 lb tumbler) with a minimum rating of a 3.5 Rating using the appropriate Commercial Reference Scale for the construction per ASTM D7330 test method. Testing without underpad or brushing.
   12. Moisture Barrier: Moisture Penetration by Impact Test: No penetration of backing after 10,000 impacts @ 10 psi.

SUSTAINABILITY
13. NSF/ANSI 140 the Sustainability Assessment for Carpet.
   a. VOC Chamber Testing
      ASTM D-5116: Product inclusive of “dry” adhesive system meets criteria established by the State of Washington Indoor Air Quality Specification for Carpet and/or Carpet & Rug Institute’s (CRI) Indoor Air Quality Carpet Testing Program. If “dry” adhesive (2.02D) not available from manufacturer and “wet” adhesive is used to install the product, carpet and adhesive to meet CRI’s Green Label requirements.

2.4 SUBSTITUTES/ALTERNATES
A. Subject to compliance with all requirements, “or equal” must match the selected colors, have similar aesthetic, and meet performance criteria.. Substitution sample and submittals to be considered must be
submitted for written approval of quality and color in accordance with bidding documents. Sample of proposed substitute must be inclusive of both the face and proposed backing (color-only sample not acceptable).

2.5 ACCESSORIES

A. Adhesives: Product to be installed using manufacturer’s recommended adhesive. Non adhesive methods are preferred and should be provided if available.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prepare sub-floor to comply with criteria established in Manufacturer’s installation instructions. Use only preparation materials that are acceptable to the Manufacturer.
   1. Remove all deleterious substances from substrate(s) that would interfere with or be harmful to the installation. (i.e. floor wax)
   2. Remove sub-floor ridges and bumps. Fill cracks, joints, holes, and other defects.

B. Verify that sub-floor is smooth and flat within specified tolerances and ready to receive carpet.

C. Verify that substrate surface is dust-free and free of substances that would impair bonding of product to the floor.

D. There will be no exceptions to the provisions stated in the Manufacturer’s installation instructions.

3.2 INSTALLATION, GENERAL

A. Where demountable partitions or other items are indicated for installation on top of finished carpet tile floor, install carpet tile before installation of these items.

B. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings.

C. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

D. Install borders parallel to walls (where applicable).

E. Trim carpet neatly at walls and around interruptions.

F. Completed carpet is to be smooth and free of bubbles, puckers, and other defects.

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Remove excess adhesive and/or seam sealer from floor and wall surfaces without damage.

B. All rubbish, wrappings, debris, trimmings, etc. to be removed from site and disposed of properly.

C. Clean and vacuum carpet surfaces per manufacturer’s instructions.

D. After each area of carpet is installed, protect from soiling and damage by other trades.

END OF SECTION 09 68 13
SECTION 09 68 16 - SHEET CARPETING

PART 1 - GENERAL

1.1 PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Sheet Carpeting is not acceptable unless approved by the University Project Manager.

1.2 SUBMITTALS

A. Review shop drawings for pattern match, if any, for matching during installation and possible waste factors in ordering required amounts. Provide copy of approved shop drawings on job site during installation.

B. Verification Samples: Submit two 18” x 18” samples illustrating color and pattern for each carpet material specified.

C. Manufacturer’s Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications
   1. Upon request, Provide a representative to assist in project start-up and to inspect installation while in process and upon completion.
      a. Representative will notify designated contact if any installation instructions are not followed.
      b. Representative will be present at 6 month and 11 month punch walks.
   2. Minimum 1 year documented experience in manufacturing of sheet carpeting.

B. Installer Qualifications
   1. Flooring contractor must be certified by the carpet manufacturer prior to bid.
   2. Flooring contractor to be a specialty contractor normally engaged in this type of work and have prior experience in the installation of these types of materials.
   3. Flooring contractor will be responsible for proper product installation, including floor testing and preparation, as specified by the carpet manufacturer and job conditions herein.

C. Single Source Responsibility: Obtain each type of carpet from one source and by a single manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in manufacturer’s original packaging listing manufacturer’s name, product name, identification number, and related information.

B. Store in a dry location, between 60 degrees F and 80 degrees F and a relative humidity below 65%. Protect from damage and soiling. Stack carpet rolls horizontally on a flat surface, stacked no higher than two rolls.

C. Make stored materials available for inspection by The University’s representative.

D. Store materials in area of installation for minimum period of 48 hours prior to installation.
1.5 PROJECT CONDITIONS

A. Include sub-floor preparation in all required work to prepare the existing floor for installation of the product as specified in this document and Manufacturer’s installation instructions.

B. Comply with 09 00 00 – Finishes, Part 3.1 for preparation of concrete to receive moisture sensitive flooring.

C. Provide all material used in sub-floor preparation and repair as recommended by the carpet manufacturer and chemically and physically compatible with the carpet system being bid.

D. Maintain minimum 65 degrees F ambient temperature and 65% Relative Humidity for 72 hours prior to, during, and 48 hours after installation.

E. Do not install carpet until space is enclosed and weatherproof, wet-work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

F. Extra Materials: Refer to Section 01 78 46 – Extra Stock Materials.

1.6 WARRANTY

A. Warranty to be sole source responsibility of the Manufacturer. Second source warranties and warranties that involve parties other than the carpet manufacturer are unacceptable.

B. If the product fails to perform as warranted when properly installed and maintained, repair and replace the affected area at the discretion of the Manufacturer.

C. Include carpet product installed on stairs in warranty provided it is properly installed and maintained.

D. Provide warranty for a specifically defined non-prorated period of 10 years to cover the following. “Lifetime” warranties are not acceptable.
   1. Excessive Surface Wear: More than 10% loss of pile fiber weight
   2. Excessive Static Electricity: More than 3.5 kV per AATCC 134; 3.0 kV in areas of heavy electronic usage
   3. No Delamination
   4. No Edge Ravel
   5. No Zippering

E. Tuft Bind warranty in lieu of edge ravel and zipperings is not acceptable.

PART 2 - PRODUCTS

2.1 MATERIALS

A. CARPET
   1. Nylon Fiber: Fiber must be premium branded nylon. Mill extruded nylon will not be accepted. 100% type 6,6 bulk continuous filament (BCF) nylon. Hollow filament fiber shape for optimal soil hiding capability. A modification ratio of less than 1.5. Polymer identification to AATCC TM 20.
   2. Construction: Texture - level loop or textured loop with maximum pile height variation of 1/32 inch.
   4. Pile Density: Minimum 5500 for heavy or severe traffic.
   5. Dye Method: Fiber to be minimum 75% solution dyed; 95% preferred.
6. Stain Resistance: AATCC TM 171 (HWE) for 2 cleanings to simulate removal of topical treatments by hot water extraction, followed by AATCC TM 175 Stain Resistance test; minimum rating of 8 using AATCC Red 40 Stain Scale.

7. Soil Resistance: Soil resistance treatment to be heat cured by mill during manufacturing process. Coloration/Patterning: Minimum five (5) color hues. Recommended: Hue values to be in medium to medium-dark range with random or complex patterning for optimum soil hiding capability. Restrict solid color carpet to accent areas. Do not use light colors.

B. BACKING CHARACTERISTICS

1. Primary Backing: Synthetic Woven or Non-Woven.
2. Pre-Coat (Fusion Coat): Sealant Vinyl
   a. High performance; Impermeable to moisture and airflow
   b. Provide for a chemically welded seam that is also impermeable to moisture and airflow
   c. 6’ Width Roll Goods

2.2 PERFORMANCE CHARACTERISTICS

A. Test reports for the following performance assurance testing to be submitted upon request. Submitted results shall represent average results for production goods of the referenced style.

B. Requirements listed below must be met by all products.

1. Flooring Radiant Panel: ASTM E-648 / NFPA 253: Class 1 (CRF: 0.45 watts/sq cm or greater)
2. Federal Flammability: CPSC FF 1-70: Passes (must pass Methenamine Pill test, ASTM D2859 test method)
4. Electrostatic Propensity: AATCC TM 134 (Step & Scuff): 3.5 kV or less by permanent means (i.e. antistatic filaments) and without chemical treatment. 3.0 kV in areas of heavy electronic usage
5. Static Coefficient of Friction:ASTM C-1028: Passes ADA Guidelines for Accessible Routes (Minimum 0.60)
7. Colorfastness to Light: AATCC TM 16.3 to 200 AFU; minimum rating 3-4 using AATCC Grey Scale for color change.
8. Colorfastness to atmospheric contaminants: AATCC TM 164 (resistance to fade from oxides of nitrogen) and AATCC TM 129 (resistance to fade from ozone) for 2 cycles; minimum rating of 3-4 using AATCC Gray Scale for Color Change.
9. Colorfastness to crocking: AATCC TM 165, minimum rating of 4 using the AATCC Chromatic Transference Scale
11. Texture Retention: Vettermann Drum ASTM D-5417: Minimum 3.5 @ 22,000 cycles or Hexapod Test Method, ASTM D5252, for 12,000 cycles (8.4 lb tumbler) with a minimum rating of a 3.5 Rating using the appropriate Commercial Reference Scale for the construction per ASTM D7330 test method. Testing without underpad or brushing.
12. Moisture Barrier: Moisture Penetration by Impact Test: No penetration of backing after 10,000 impacts @ 10 psi.
13. Moisture Barrier: Moisture Penetration by Impact @ 10 psi: No Penetration of backing and seam after 10,000 impacts
14. Air Flow Barrier: Air Permeability of Textile Fabrics: No Air Flow (0.0 ft³/min) through backing and seam
15. Seam Integrity: Seam to remain intact after 50,000 cycles per Phillips Chair Test

2.3 SUSTAINABILITY

A. VOC Chamber Testing : ASTM D-5116: Product inclusive of “dry” adhesive system meets criteria established by the State of Washington Indoor Air Quality Specification for Carpet and/or Carpet & Rug
Institute’s (CRI) Indoor Air Quality Carpet Testing Program. If “dry” adhesive (2.02D) not available from manufacturer and “wet” adhesive is used to install the product, carpet and adhesive to meet CRI’s Green Label requirements.

B. NSF/ANSI 140 the Sustainability Assessment for Carpet.

2.4 SUBSTITUTES/ALTERNATES

A. Subject to compliance with all requirements, “or equal” must match the selected color(s), have similar aesthetic appearance and tuft density, closed-cell vinyl backing, and meet the performance criteria. Substitution sample and submittals to be considered must be submitted for written approval of quality and color in accordance with bidding documents. Sample of proposed substitute must be inclusive of both the face and proposed backing (color-only sample not acceptable).

2.5 ACCESSORIES

A. Materials recommended by Manufacturer for patching, priming, chemically welding the seams, etc.

B. Adhesives: Products to be supplied with a pre-cured, mill-applied or other “dry” adhesive system (2.02E) when available. Otherwise, adhesive should be full spread, extremely low VOC in compliance with CRI Indoor Air Quality Adhesive Testing Program requirements, compatible with materials being adhered, as recommended by the Manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prepare sub-floor to comply with criteria established in Manufacturer’s installation instructions. Use only preparation materials that are acceptable to the Manufacturer.

1. Remove all deleterious substances from substrate(s) that would interfere with or be harmful to the installation. *(i.e. floor wax)*

2. Remove sub-floor ridges and bumps. Fill cracks, joints, holes, and other defects.

B. Verify that sub-floor is smooth and flat within specified tolerances and ready to receive carpet.

C. Verify that substrate surface is dust-free and free of substances that would impair bonding of product to the floor.

D. There will be no exceptions to the provisions stated in the Manufacturer’s installation instructions.

3.2 INSTALLATION, GENERAL

A. Install product in accordance with Manufacturer’s installation instructions.

B. Verify carpet match before cutting to ensure minimal variation between dye lots.

C. Layout carpet and locate seams in accordance with shop drawings.

1. Locate seams in area of least traffic, out of areas of pivoting traffic, and parallel to main traffic. Minimize cross seams.

2. Do not locate seams perpendicular through door openings.

3. Align run of pile in same direction as anticipated traffic and in same direction on adjacent pieces.
4. Locate change of color or pattern between rooms under door centerline.
5. Provide monolithic color, pattern, and texture match within any one area.

D. Install carpet tight and flat on sub-floor, well-fastened at edges, with a uniform appearance.
E. Double-cut carpet seams with accurate pattern match. Make cuts true, and unfrayed.
F. Chemically weld all seams with manufacturer’s recommended seam sealer as stated in installation instructions. Make sure the seam is fully sealed.
G. Where demountable partitions or other items are indicated for installation on top of finished carpet, install carpet before installation of these items.
H. Cut and fit carpet to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings.
I. Extend carpet into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.
J. Install borders parallel to walls (where applicable).
K. Roll with appropriate roller for complete contact of carpet with mill-applied adhesive to sub-floor.
L. Trim carpet neatly at walls and around interruptions.
M. Completed carpet is to be smooth and free of bubbles, puckers, and other defects.

3.3 TESTING, CLEANING, AND CERTIFICATION
A. Remove excess adhesive and/or seam sealer from floor and wall surfaces without damage.
B. All rubbish, wrappings, debris, trimmings, etc. to be removed from site and disposed of properly.
C. Clean and vacuum carpet surfaces using a beater brush/bar commercial vacuum.
D. After each area of carpet is installed, protect from soiling and damage by other trades.

END OF SECTION 09 68 16
SECTION 09 72 00 - WALL COVERINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
   1. Vinyl Wall Covering:
      a. Vinyl wall covering must be approved for desired location through the University Project Manager. The surface should be smooth and resistant to high alkaloid cleansers.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Vinyl Wall Covering: Type II, Medium or Type III, Heavy Duty per FS CCC-W-408D and CFFA-W-101D, mildew resistant and with stain-resistant coating.
   1. Strippable, complying with ASTM F 793 for one of the following:
      a. Category IV, Type I, Commercial Serviceability
      b. Category V, Type II, Commercial Serviceability
      c. Category VI, Type III, Commercial Serviceability.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 09 72 00
SECTION 09 77 33 - PLASTIC WALL SURFACING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide fiber reinforced plastic (FRP) panels on all walls in wet areas.

PART 2 - PRODUCTS

2.1 FIBER REINFORCED PLASTIC (FRP) WALL PANELS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Marlite FRP or a comparable product.

B. Accessories:
   1. Extruded PVC Trim: Base, inside corner, outside corner, sheet dividers and edge.
   2. Adhesive.
   3. Sealant.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in strict conformance with manufacturer’s installation instructions. Seal all seams and joints.

END OF SECTION 09 77 33
SECTION 09 91 23 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Single-Source Responsibility: Provide primers and undercoats produced by and certified compatible with each other and with topcoat.
   2. Quality: Provide manufacturer’s first line commercial products.
   3. Locally Available: Provide products readily available within the Denver metropolitan area in 1- and 5-gallon containers. Readily available means within 24-hours of placing order.
   4. Dry Film Thickness (DFT): Apply all coatings in strict conformance with manufacturer’s recommendations for minimum DFT.

1.2 SUBMITTALS

A. MSDS: Contractor to provide Material Safety Data Sheets (MSDS) for all coatings to the University Project Manager prior to application.

1.3 QUALITY ASSURANCE

A. MPI Standards: Provide products that comply with Master Painter Institute (MPI) standards indicated and that are listed in its "MPI Approved Products List."

B. All painting must be of journeyman level craftsmanship, paying special attention to preparation, etching, priming and undercoating.

PART 2 - PRODUCTS

2.1 BLOCK FILLERS

A. Block Filler, Acrylic/Latex, Interior/Exterior for Concrete Masonry Unit Substrates: MPI #4

2.2 PRIMERS/SEALERS

A. Primer, Alkali Resistant, Water Based, for Concrete Substrates: MPI #3

B. Primer Sealer, Interior, Institutional Low Odor/No VOC, for Gypsum Board and Plaster Substrates: MPI #149

C. Primer, Latex, for Interior Wood Substrates: MPI #39

D. Wood-Knot Sealer: Sealer recommended in writing by topcoat manufacturer for use in paint systems indicated.

2.3 METAL PRIMERS

A. Primer, Rust-Inhibitive, Water Based, for Ferrous-Metal Substrates: MPI #107

B. Primer, Galvanized, Water Based, for Zinc-Coated Metal Substrates: MPI #134

C. Primer, Quick Dry, for Aluminum Substrates: MPI #95
2.4 WATER-BASED PAINTS

A. Latex, Interior, Gloss (Gloss Level 6, except minimum gloss of 65 units at 60 degrees): MPI #114.
B. Latex, Interior, Institutional Low Odor/No VOC, Flat (Gloss Level 1): MPI #143.
C. Latex, Interior, Institutional Low Odor/No VOC, Egg-Shell (Gloss Level 2) MPI #144 or (Gloss Level 3) MPI #145.
D. Latex, Interior, Institutional Low Odor/No VOC, Semi-Gloss (Gloss Level 5): MPI #147.

2.5 DRY FOG/FALL COATINGS

A. Dry Fall, Latex, Flat: MPI #118.
B. Dry Fall, Water Based, for Galvanized Steel, Flat (Gloss Level 1): MPI #133.

2.6 FLOOR COATINGS

A. Sealer, Water Based, for Concrete Floors: MPI #99.

PART 3 - EXECUTION

3.1 INTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces: The following system is acceptable, high performance coating specified in SECTION 09 96 00 preferred.

1. Institutional Low-Odor/No VOC Latex System: MPI INT 3.1M
   a. Prime Coat: Primer sealer, interior, institutional low odor/No VOC, MPI #149.
   c. Topcoat: Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

B. Concrete Substrates, Traffic Surfaces: At all concrete traffic surfaces scheduled to receive sealer.

1. Water-Based Clear Sealer System: MPI INT 3.2G
   a. First Coat: Sealer, water based, for concrete floors, MPI #99.
   b. Topcoat: Sealer, water based, for concrete floors, MPI #99.

C. CMU Substrates: The following system is acceptable, high performance coating specified in SECTION 09 96 00 preferred.

1. Institutional Low-Odor/No VOC Latex System: MPI INT 4.2E
   c. Topcoat: Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

D. Steel Substrates: At all steel substrates not indicated to receive high-performance coatings specified in SECTION 09 96 00.

1. Water-Based Dry-Fall System (for overhead work only): MPI INT 5.1C
   a. Prime Coat: Shop primer to be specified in Division 05.
   b. Topcoat: Dry fall, latex, flat, MPI #118.
2. Institutional Low-Odor/No VOC Latex System: MPI INT 5.1S
c. **Topcoat:** Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

**E.** Galvanized-Metal Substrates: At all galvanized metal substrates not indicated to receive high-performance coatings specified in SECTION 09 96 00.
   1. **Water-Based Dry-Fall System (for overhead work only):** MPI INT 5.3H
      a. **Prime Coat:** Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.
      b. **Topcoat:** Dry fall, water based, for galvanized steel, flat (Gloss Level 1), MPI #133.
   2. **Institutional Low-Odor/No VOC Latex System:** MPI INT 5.3N
      a. **Prime Coat:** Primer, galvanized, water based, MPI #134.
      b. **Intermediate Coat:** Latex, interior, institutional low odor/No VOC, matching topcoat.
      c. **Topcoat:** Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

**F.** Aluminum (Not Anodized or Otherwise Coated) Substrates:
   1. **Institutional Low-Odor/No VOC Latex System:** MPI INT 5.4G
      a. **Prime Coat:** Primer, quick dry, for aluminum, MPI #95.
      b. **Intermediate Coat:** Latex, interior, institutional low odor/No VOC, matching topcoat.
      c. **Topcoat:** Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

**G.** Wood Substrates:
   1. **Institutional Low-Odor/No VOC Latex System:** MPI INT 6.1Q, MPI INT 6.2L, MPI INT 6.3V, and MPI INT 6.4T
      a. **Prime Coat:** Primer, latex, for interior wood, MPI #39.
      b. **Intermediate Coat:** Latex, interior, institutional low odor/No VOC, matching topcoat.
      c. **Topcoat:** Latex, interior, institutional low odor/No VOC, semi-gloss (Gloss Level 5), MPI #147.

**H.** Gypsum Board and Plaster Substrates:
   1. **Latex System:** MPI INT 9.2A. At gypsum board, GFRG, and plaster substrates scheduled to receive gloss paint.
      a. **Prime Coat:** Primer sealer, latex, interior, MPI #50.
      b. **Intermediate Coat:** Latex, interior, matching topcoat.
      c. **Topcoat:** Latex, interior; gloss, (Gloss Level 6, except minimum gloss of 65 units at 60 degrees), MPI #114.
   2. **Institutional Low-Odor/No VOC Latex System:** MPI INT 9.2M. At all gypsum board, GFRG, and plaster substrates, unless indicated otherwise.
      a. **Prime Coat:** Primer sealer, interior, institutional low odor/No VOC, MPI #149.
      b. **Intermediate Coat:** Latex, interior, institutional low odor/No VOC, matching topcoat.
      c. **Topcoat:** Latex, interior, institutional low odor/No VOC; Provide one of the following as indicated in Finish Schedule:
         1) **Flat** (Gloss Level 1), MPI #143
         2) **Egg-shell** (Gloss Level 2), MPI #144 or (Gloss Level 3), MPI #145
         3) **Semi-gloss** (Gloss Level 5), MPI #147
      d. **Typical Sheen:** Egg-shell (Gloss Level 2 or 3) unless indicated otherwise.

END OF SECTION 09 91 23
SECTION 09 96 00 - HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide high-performance coatings on all exterior surfaces and where durable finishes are required on interior surfaces.
   2. Provide fiber-reinforced epoxy paint at vivariums.

1.2 SUBMITTALS:

A. MSDS: Contractor to provide Material Safety Data Sheets (MSDS) for all coating to the University Project Manager prior to application.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide listed products by Tnemec or a comparable product by one of the following:
   1. Carboline, an RPM company.
   2. PPG Architectural Finishes, Inc.

2.2 BLOCK FILLERS

A. Block Filler, Waterborne Cementitious Acrylic:

2.3 METAL FILLER/SURFACER

A. Filler/Surfacer, Modified Amine Epoxy Filler.

2.4 INTERIOR PRIMERS/SEALERS

A. Primer Sealer, Modified Polyamine Epoxy, Interior:

2.5 METAL PRIMERS

A. Primer, Zinc-Rich, Urethane:

B. Primer, Epoxy:

2.6 EPOXY COATINGS

A. Waterborne Epoxy, Semi-gloss:

B. Polyamidoamine Epoxy, Semi-gloss:
1. Basis-of-Design Product: Tnemec; Series L69 – Hi-Build Epoxoline II.

C. Modified Polyamine 100 Percent Solids Epoxy, Gloss:

2.7 POLYURETHANE COATINGS

A. Aliphatic Acrylic Polyurethane, Two-Component, Semi-Gloss:
   1. Basis-of-Design Product: Tnemec; Series 750 – Endura-Shield

B. Ceramic-Modified, Waterborne, Aliphatic Polyurethane, Two-Component, Gloss.

2.8 ELASTOMERIC COATINGS

A. Acrylate Elastomer, Matte:

2.9 FIBER REINFORCED EPOXY WALL COATING

A. Fiber reinforced epoxy: Two-part, spray-applied, fiber reinforced, 100 percent solids, accelerated aliphatic amine cured epoxy system with non-leaching antimicrobial additives.

PART 3 - EXECUTION

3.1 EXTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Concrete Substrates, Vertical Surfaces:
   1. Elastomeric System:
      b. Prime Coat: To match topcoat; DFT 4.0 to 8.0 mils.
      c. Topcoat: Acrylate elastomer, matte; DFT 4.0 to 8.0 mils. Total DFT: 8.0 to 16.0 mils.

B. CMU Substrates:
   1. Elastomeric System: At all CMU locations schedule to receive paint.
      a. Surface Preparation: Clean and dry.
      b. Block Filler: Block filler, waterborne cementitious acrylic.
      c. Intermediate Coat: Acrylate elastomer, matte; DFT 4.0 to 8.0 mils.
      d. Topcoat: Acrylate elastomer, matte; DFT 4.0 to 8.0 mils. Total DFT: 8.0 to 16.0 mils.

C. Steel Substrates:
   1. Pigmented Polyurethane over Zinc-Rich Primer System: At all exterior exposed structural steel and miscellaneous metals unless noted otherwise.
      b. Prime Coat: Primer, zinc-rich, urethane; DFT 2.5 to 3.5 mils.
      c. Intermediate Coat: Polyamidoamine epoxy; DFT 2.0 to 4.0 mils.
      d. Topcoat: Aliphatic, polyurethane, two-component, pigmented, semi-gloss; DFT 3.0 to 4.0 mils. Total DFT: 7.5 to 11.5 mils.

D. Galvanized-Metal Substrates:
   1. Pigmented Polyurethane System: At all exterior exposed galvanized metal.
      a. Surface Preparation: Abrasive blast or chemically cleaned and etched.
      b. Prime Coat: Primer not required; intermediate coat is self-priming.
      c. Intermediate Coat: Polyamidoamine epoxy; DFT 2.0 to 4.0 mils.
d. Topcoat: Aliphatic, polyurethane, two-component, pigmented, semi-gloss; DFT 3.0 to 4.0 mils.

e. Total DFT: 5.0 to 8.0 mils.

3.2 INTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Concrete Substrates, Vertical Surfaces:
   1. Epoxy/Polyurethane System:
      a. Surface Preparation: SSPC-SP 13/NACE 6, clean and dry.
      b. Prime Coat: To match intermediate coat; DFT 2.0 to 3.0 mils.
      c. Intermediate Coat: Waterborne epoxy, semi-gloss; DFT 2.0 to 3.0 mils. Topcoat: Ceramic-modified, waterborne, two-component, aliphatic polyurethane, gloss; DFT 2.0 to 3.0 mils.
      d. Total DFT: 6.0 to 9.0 mils.

B. CMU Substrates:
   1. Epoxy/Polyurethane System: At all CMU locations scheduled to receive paint unless otherwise indicated.
      a. Surface Preparation: Clean and dry.
      b. Block Filler: Block filler, waterborne cementitious acrylic.
      c. Primer: To match intermediate coat; DFT 2.0 to 3.0 mils.
      d. Intermediate Coat: Waterborne epoxy, semi-gloss; DFT 2.0 to 3.0 mils.
      e. Topcoat: Ceramic-modified, waterborne, two-component, aliphatic polyurethane, gloss; DFT 2.0 to 3.0 mils.
      f. Total DFT: 6.0 to 9.0 mils.

   2. 100 Percent Solids Epoxy System: At all CMU locations in areas subject to continuous wetting, for example, shower stalls.
      a. Surface Preparation: Clean and dry.
      b. Block Filler: Block filler, waterborne cementitious acrylic.
      c. Primer: To match topcoat; DFT 6.0 to 8.0 mils.
      d. Topcoat: Modified polyamine, 100 percent solids epoxy, gloss; DFT 6.0 to 8.0 mils.
      e. Total DFT: 12.0 to 16.0 mils.

C. Steel Substrates:
   1. Pigmented Polyurethane System: At all exposed structural steel, miscellaneous metals.
      b. Prime Coat: To match intermediate coat; DFT 2.0 to 3.0 mils.
      c. Intermediate Coat: Polyamidoamine epoxy; DFT 2.0 to 4.0 mils.
      d. Topcoat: Aliphatic, polyurethane, two-component, pigmented, semi-gloss; DFT 3.0 to 4.0 mils.
      e. Total DFT: 7.0 to 10.0 mils.

   2. Pigmented Polyurethane System over Manufacturer’s Standard Primer: At all interior painted hollow metal doors and frames, handrails, guardrails, stairs, ladders and ship’s ladders.
      a. Prime Coat: Manufacturer’s standard universal primer.
      b. Intermediate Coat: Polyamidoamine epoxy; DFT 2.0 to 3.0 mils.
      c. Topcoat: Aliphatic, polyurethane, two-component, pigmented, semi-gloss; DFT 3.0 to 4.0 mils.

D. Galvanized-Metal Substrates:
   1. Pigmented Polyurethane System: At all interior exposed galvanized metal.
      a. Surface Preparation: Abrasive blast or chemically cleaned and etched.
      b. Prime Coat: Primer not required; intermediate coat is self-priming.
      c. Intermediate Coat: Polyamidoamine epoxy; DFT 2.0 to 4.0 mils.
      d. Topcoat: Aliphatic, polyurethane, two-component, pigmented, semi-gloss; DFT 3.0 to 4.0 mils.
      e. Total DFT: 5.0 to 8.0 DFT.
E. Gypsum Board Substrates:
   1. Epoxy/Polyurethane System: At all gypsum board surfaces scheduled to receive high-performance coatings.
      a. Surface Preparation: Level 5 finish.
      b. Prime Coat: Primer sealer, modified polyamine epoxy; DFT 4.0 to 6.0 mils.
      c. Intermediate Coat: Waterborne epoxy, semi-gloss; DFT 2.0 to 3.0 mils.
      d. Topcoat: Ceramic-modified, waterborne, two-component, aliphatic polyurethane, gloss; DFT 2.0 to 3.0 mils.
      e. Total DFT: 8.0 to 12.0 mils.

END OF SECTION 09 96 00
SECTION 10 11 00 - VISUAL DISPLAY UNITS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Chalk Boards:
      a. Not permitted.
   2. Marker Boards:
      a. Consult with the University Project Manager and the University Educational Support Services for marker board use.

1.2 WARRANTY

A. Materials and Workmanship for Porcelain-Enamel Face Sheets: 50 years.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Porcelain-Enamel Face Sheet: Manufacturer's standard steel.

B. Markerboard Assemblies: Porcelain enamel.
   1. Manufacturers:
      a. Best-Rite Manufacturing.
      b. Claridge Products and Equipment, Inc.
      c. Egan Visual Inc.
      d. PolyVision Corporation; a Steelcase company.

C. Markerboard Accessories:
   1. Aluminum frames.

2.2 FABRICATION


PART 3 - EXECUTION (Not Applicable)

END OF SECTION 10 11 00
SECTION 10 14 00 - SIGNAGE

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
1. Comply with Part 1.6, B for room and door numbering and Part 1.6, C for elevator numbering.
2. Include all interior signs within the construction contract.
3. Update existing signage to meet current standards for renovation projects.
   a. The signage system may be customized with input from the Facility Operations, the building administer through the University Project Manager.
   b. Exemption: Lawrence Street Center and CU Denver Building. Match signage to existing building signage.

1.2 DEFINITIONS

A. Way Finding Signs:
1. Type A1 – Directional by Department: Place one wall mounted sign at each corridor junction and main entry points in each building. Two signs may used as required. Indicate which direction to go for each department, conference room, etc. Location to be most readily visible to the preponderance of the traffic flow at the intersection. The size of the sign can vary depending on the quantity of department names desired.
2. Type A2 – Directional by Room Number: Place one overhead sign at each corridor junction where a wall is not available to accept a Type A1 sign. Indicate room number ranges in lieu of departments.
3. Type B1 - Room Identification (Room Number with Paper Insert):
   a. At each active corridor entrance to a room, install a sign with the room number. Not used for mechanical, electrical, janitorial, telecom, restrooms, or most storage rooms.
   b. Paper insert (Sign Type H) content may vary and can include the following information: Administrative unit name, the name(s) if each individual(s) working in the room, and individual’s title (this will be the department’s option). Coordinate with the University Project Manager.
   c. Top of sign to be 60” from the finished floor surface on the latch side of the door, with the sign edge one inch from the door frame. Where architectural constraints preclude this location, the Building Administrator will determine an alternate location through the University Project Manager.
4. Type B2 – Suite Identification (Room Number with Paper Insert):
   a. At each active corridor entrance to a suite, install a sign with the range of room numbers. Not used for mechanical, electrical, janitorial, telecom, restrooms, or most storage rooms.
   b. Paper insert (Sign Type H) content may vary and can include the following information: Administrative unit name, the name(s) if each individual(s) working in the room, and individual’s title (this will be the department’s option). Coordinate with the University Project Manager.
   c. Top of sign to be 60” from the finished floor surface on the latch side of the door, with the sign edge one inch from the door frame. Where architectural constraints preclude this location, the Building Administrator will determine an alternate location through the University Project Manager.
5. Type B3 – Room Identification (no number): Typically used for additional suite or room information. Mount directly below sign type B1 or B2.
6. Type B4 – Identification Frame: Typically used to hold unique sign plaques.
7. Type C - Room Number: Where Room Identification Signs (Type B1 or B2) are not installed, provide a room number sign at each doorway from a corridor into a room, and each doorway from one room into an adjoining room. These signs are used for mechanical, electrical, janitorial, telecom, restrooms, and most storage rooms.
a. Provide room number signs on the corridor side of the door frame.
b. Mount on the head of the door frame, centered above the door.
c. Mount at door header height when used to identify lab alcoves and bays.

8. Type D - Restroom Identification: Used in addition to sign type C. Provide at the corridor side to designate use as men, women, unisex or shower. Sign information will show ADA accessibility as applicable.
   a. Top of sign to be 60” from the finished floor surface on the latch side of the door, with the sign edge one inch from the door frame. Where architectural constraints preclude this location, the Building Administrator will determine an alternate location through the University Project Manager.

9. Type E - Unique Door Identification: Where a door number is not the same as a room number (i.e. more than one door into a room) or where doors separate portions of corridors and are not associated with a room number, install signs identifying the “unique” door number.
   a. Mount right justified on the corridor side of the door header.
   b. Mount right justified on the both sides of the door header at doors separating portions of corridors or between two rooms.

10. Type F - Exterior Door Identification: At the exterior face of all exterior doors, mount exterior door identification signs on the head of the door frame, centered above the door to identify the designated door number.

11. Type G - Elevator Identification: Mount centered on elevator door frame head at each elevator. Include the University building number and elevator cab number.

12. Type H – Paper Insert: For use with Type B1, B2, and B4. Coordinate information to be printed on paper insert with the University Project Manager.

B. Safety/Code Signs:
   1. Type L - Room Capacity: Locate at the main exit from the room.
   2. Type M1 - Outside the Stair/Stairwell: Mount adjacent to door leading into the stairwell.
   3. Type M2 – Outside the Transitional Stair/Stairwell: Mount adjacent to door leading into the stairwell.
   4. Type N - Inside the Stair/Stairwell: Mount adjacent to door leading out of the stairwell.
   5. Type P – Caution: Provide at entry to lab suites, lab alcoves, procedure rooms, dark rooms and environmental rooms. For use with Type B4. Mount below Type B signs, where applicable.
   6. Type Q – Emergency Quick Reference Guide: Mount in every public space or room, classrooms, laboratories, meeting spaces, and near red phones. Can be used to display non-emergency information.

C. Notices and Displays: Coordinate locations with the University Project Manager.
   1. Type S – Elevator Notice and Display Panels: Mount inside the elevator cab.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: ASI Sign Systems; ASI Interior 20 Series.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. ASI Sign Systems, Inc; 303-755-0997
   2. Forum Engraving; 303-761-8084
   3. Art Form Signs; 303-975-4641

2.2 SIGNAGE MATERIALS/COMPONENTS

A. Product
   1. Ceiling Mounted, Projected, and Wall Mounted Signs:
      a. Text or Graphic Technique: Screen process
2. Interior “Paperflex” “Inhouse” Updatable Signs
3. Vinyl Die Cut Characters

B. Materials and Components
1. Fixture Aluminum Panels: Extruded aluminum, alloy AA6060, with high temperature cured polyester color coating. Provide one piece formed aluminum/photopolymer panel for ADA-Ready sizes of 3-1/4” (82.5mm) high and above.
2. Face Components:
   a. ADA-Ready Panels: Aluminum-based ASI Intouch photopolymer tactile and Braille characters with high temperature cured polyester color coating.
   b. Graphic Panels: High-strength, cold-rolled, 1/32” (0.75 mm) aluminum alloy with high temperature cured polyester coating.
3. End Clips:
   a. ASI 6” and 8” ADA-Ready Panels Extruded aluminum, alloy AA6060, with high temperature cured polyester color coating or similar.
   b. ASI Panels: Injection molded plastic or similar
4. Mounting Hardware:
   a. Wall Rails: Extruded aluminum, alloy AA6060, track-type rail mounted to wall with manufacturer recommended mechanical fasteners or similar.
   b. Adhesive: 3M VHB Adhesive Transfer Tape.

C. Finishes:
1. Colors:
   a. Type B Room Identification Signs:
      1) Main Background Color: SC-903 Medium Grey
      2) Room number and dash: SC-906 Cool Grey
      3) Rule line: SC-906 Cool Grey
      4) Paper Insert: White
   b. All Other Signs:
      1) Main Background Color: SC-903 Medium Grey
      2) Font: SC-922 Bone
      3) Rule line: SC-906 Cool Grey (where applicable)
2. Surface Treatment Finish: Manufacturer’s standard two-phase finishing process.
   a. Phase One: Chromatized priming with 2u depth chrome layer for optimum surface coat adhesion and weatherability.
   b. Phase Two: Painting process employing two component, water-based, non-toxic, lead-free, zero emissions, high temperature cured polyester coating of 20-30u deep.

D. Way Finding Signs: (Refer to Part 4 – Illustrations for graphical representation and sizes.)
1. Type A1 – Directional by Department:
   a. Header Panel: Provide 1-1/2” Helvetica Regular font for floor level number, and 3/4” Helvetica Regular font for building name.
   c. Mount: Wall Rails with Adhesive.
2. Type A2 - Directional by Room Number:
   a. Double Faced or Single Faced
   b. Text: 3” Helvetica Regular, #, Condensed 80% font. Provide uppercase letters only.
   c. Mount: Ceiling Mounted.
3. Type B1 Room Identification (Room Number with Paper Insert):
   a. Header Panel: Provide raised text, 5/8” Helvetica Regular font with 24 pt, grade II Braille 3/8” below copy. Provide uppercase letters at all letters within the room number text except the last character, where applicable.
b. Paper insert content, font, and character size may vary per building. Coordinate with the University Project Manager. Provide paper for insert and computer program with all fonts to the University.

c. Mount: Wall Rails with Adhesive.

4. Type B2 – Suite Identification (Room Number with Paper Insert):
   b. Paper insert content, font, and character size may vary per building. Coordinate with the University Project Manager. Provide paper for insert and computer program with all fonts to the University.
   c. Mount: Wall Rails with Adhesive.

5. Type B3 – Room Identification (no number):
   a. Provide 5/8” Helvetica Regular font. Coordinate text with the University Project Manager.
   b. Option: Silk Screen Symbol. Coordinate with the University Project Manager.

6. Type B4 – Identification Frame:

7. Type C – Room Number:
   a. Provide 5/8” Helvetica Regular font. Provide uppercase letters at all letters within the room number text except the last character, where applicable.
   b. Provide second surface silk-screened copy on 1/8” phenolic.
   c. Mount: Adhesive

8. Type D Restroom Identification:
   b. Mount: Wall Rails with Adhesive.

9. Type E – Unique Door Identification:
   a. Provide 5/8” Helvetica Regular font. Provide uppercase letters at all letters within the door number text except the last character, where applicable.
   b. Vinyl die-cut alpha numeric characters.
   c. Provide appropriate contrast with door frame color to meet all applicable code requirements.

10. Type F – Exterior Door Identification:
    a. Provide Door Number information in 5/8” Helvetica Regular. Provide uppercase letters only.
    b. Provide second surface silk-screened copy on 1/8” phenolic.
    c. Mount: Adhesive

11. Type G – Elevator Identification:
    a. Provide 5/8” Helvetica Regular. Provide uppercase letters only.
    b. Vinyl die-cut alpha numeric characters.

12. Type H – Paper Insert:
    a. Paper insert content, font, and character size may vary per building. Coordinate with the University Project Manager.
    b. Provide paper for insert and computer program with all fonts to the University.

E. Safety/Code Signs: (Refer to Part 4 – Illustrations for graphical representation and sizes.)

1. Type L - Room Capacity:
   a. Provide 3/8” Helvetica Regular for text; 1/2” Helvetica Regular for numerical characters. Provide uppercase letters only.
   b. Mount: Adhesive

2. Type M1 - Outside the Stairwell:
   b. Main Panel: Provide silk screened stair symbol.
   c. Mount: Wall Rails with Adhesive.

3. Type M2 – Outside the Transitional Stair/Stairwell:

b. Main Panel: Provide 1/2" Helvetica Regular. Provide uppercase letters only. Provide silk screened stair symbol.

c. Mount: Wall Rails with Adhesive.

4. Type N – Inside the Stairwell:
   a. Provide Helvetica Regular font with 24 pt, grade II Braille 3/8” below copy. Provide uppercase letters only.
   
   b. Comply with UFC text size requirements
   
   c. Mount: Adhesive

5. Type P – Caution:
   a. Coordinate with Environmental Health and Safety (EHS) through the University Project Manager.

6. Type Q – Emergency Quick Reference Guide:
   a. Basis of Design: Deflect-O Classic Image Wall Mount Sign Holder, Clear, 8-1/2”x11” Portrait
   

F. Notices and Displays
1. Type S – Elevator Notice and Display Panels
   a. Provide window sign with 1/8” Clear Acrylic Panels.
   
   b. Provide 1/4” stainless steel accent strips at header and footer panels. Refer to Part 4 - Illustration.
   
   c. Provide Gyford Aluminum 3/16” barrel with cap; Brushed finish. Adhere caps.
   
   d. Mount: Anchors set in wall surface.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Mounting
   1. Mount all signs in accordance with ICC/ANSI 117.1-2003 and ADAAG requirements.
PART 4 - ILLUSTRATIONS

4.1 Type A1 – Directional by Department

![Typical A1 Sign](image1)

![Shorter A1 Sign Option](image2)
4.2 Type A2 – Directional by Room Number

4.3 Type B1 – Room Identification (Room Number with Paper Insert)

4.4 Type B2 – Suite Identification (Room Number with Paper Insert)
4.5 Type B3 – Room Identification (no number)

MESSAGE TBD

4.6 Type B4 – Identification Frame

4.7 Type C – Room Number

Q20-E4309e
4.8  Type D - Restroom Identification

4.9  Type E – Unique Door Identification

4.10  Type F - Exterior Door Identification

4.11  Type G - Elevator Identification
4.12 Type H – Paper Insert: No Illustration Provided.

4.13 Type L: Room Capacity

4.14 Type M1: Outside the Stair/Stairwell
4.15 Type M2: Outside the Transitional Stair/Stairwell

4.16 Type N: Inside the Stair/Stairwell
4.17  Type P: Caution

4.18  Type Q – Emergency Quick Reference Guide
4.19 Type S: Elevator Notice and Display Panels

END OF SECTION 10 14 00
SECTION 10 21 13 - TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 WARRANTY

A. Special Coating Warranty: Manufacturer’s standard form in which manufacturer agrees to replace defective material.
1. Coating defects include, but are not limited to: chipping, flaking, cracking or discoloration.
2. Warranty Period: 3 years from Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Sheet: Hot-dipped galvanized, ASTM A 653/A 653M, with G90 coating.

B. Stainless-Steel Castings: ASTM A 743/A 743M.

C. Zamac: ASTM B 86, commercial zinc-alloy die castings.

2.2 STEEL UNITS

A. Manufacturer:
2. General Partitions Mfg. Corp.
3. Global Steel Products Corp.
4. Hadrian Manufacturing Inc.
5. Sanymetal; a Crane Plumbing company.

B. Toilet-Enclosure Style: Overhead braced.

C. Urinal-Screen Style: Wall hung, flat panel; post to ceiling.

D. Door, Panel, and Pilaster Construction: Seamless, metal facing sheets pressure laminated to core material; with continuous, interlocking molding strip or lapped-and-formed edge closures; corners secured by welding or clips and exposed welds ground smooth. Exposed surfaces shall be free of pitting, seam marks, roller marks, stains, discolorations, telegraphing of core material, or other imperfections.
1. Core Material: Manufacturer's standard sound-deadening honeycomb of resin-impregnated kraft paper in thickness required to provide finished thickness of 1 inch for doors and panels and 1-1/4 inches for pilasters.
2. Grab-Bar Reinforcement: Provide concealed internal reinforcement for grab bars mounted on units.
3. Tapping Reinforcement: Provide concealed reinforcement for tapping (threading) at locations where machine screws are used for attaching items to units.

E. Urinal-Screen Construction:
1. Flat-Panel Urinal Screen: Matching panel construction.

F. Facing Sheets and Closures: Hot-dip galvanized-steel sheet with nominal base-metal (uncoated) thicknesses as follows:
1. Pilasters, Braced at Both Ends: Manufacturer's standard thickness, but not less than 0.036 inch.
2. Pilasters, Unbraced at One End: Manufacturer's standard thickness, but not less than 0.048 inch.
3. Panels: Manufacturer's standard thickness, but not less than 0.030 inch.
4. Doors: Manufacturer's standard thickness, but not less than 0.030 inch.
5. Flat-Panel Urinal Screens: Thickness matching the panels.

G. Pilaster Shoes and Sleeves (Caps): Stainless-steel sheet, not less than 0.031-inch nominal thickness and 3 inches high, finished to match hardware.

H. Urinal-Screen Post: Manufacturer's standard post design of material matching the thickness and construction of pilasters; with shoe and sleeve (cap) matching that on the pilaster.

I. Brackets (Fittings):
   1. Stirrup Type: Ear or U-brackets; chrome-plated zamac acceptable; stainless steel preferred.

J. Steel-Sheet Finish: Immediately after cleaning and pretreating, apply manufacturer's standard baked-on finish, including thermosetting, electrostatically applied, and powder coatings. Comply with coating manufacturer's written instructions for applying and baking.

2.3 ACCESSORIES

A. Hardware and Accessories: Manufacturer's standard design, heavy-duty operating hardware and accessories.
   1. Material: Chrome-plated zamac.
   2. Hinges: Manufacturer's standard paired, self-closing type that can be adjusted to hold doors open at any angle up to 90 degrees.
   3. Latch and Keeper: Manufacturer's standard surface-mounted latch unit designed for emergency access and with combination rubber-faced door strike and keeper. Provide units that comply with regulatory requirements for accessibility at compartments designated as accessible.
   4. Coat Hook: Manufacturer's standard combination hook and rubber-tipped bumper, sized to prevent in-swinging door from hitting compartment-mounted accessories.
   5. Door Bumper: Manufacturer's standard rubber-tipped bumper at out-swinging doors.
   6. Door Pull: Manufacturer's standard unit at out-swinging doors that complies with regulatory requirements for accessibility. Provide units on both sides of doors at compartments designated as accessible.

B. Overhead Bracing: Manufacturer's standard continuous, extruded-aluminum head rail with antigrip profile and in manufacturer's standard finish.

C. Anchorages and Fasteners: Manufacturer's standard exposed fasteners of stainless steel or chrome-plated steel or brass, finished to match the items they are securing, with theft-resistant-type heads. Provide sex-type bolts for through-bolt applications. For concealed anchors, use stainless steel, hot-dip galvanized steel, or other rust-resistant, protective-coated steel.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 10 21 13
SECTION 10 26 23 - PROTECTIVE WALL COVERINGS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements
   1. Provide heavy duty vinyl or stainless steel (626 finish) corner guards at janitor closets.

PART 2 - PRODUCTS

2.1 Wall Guards
   1. Stainless steel with 626 finish.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 10 26 23
SECTION 10 28 00 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements:
   1. Coordinate with the University Project Manager to complete a listing of required accessories.
   2. Combination paper towel/waste receptacles are prohibited.
   3. Seat Cover Dispensers are prohibited.
   4. Sanitary Napkin/Tampon Vendors are prohibited.
   5. Provide surface mounted accessories.
   6. Locate Electric hand dryer to be primary choice to dry hands over paper towel dispenser.

PART 2 - PRODUCTS

2.1 ACCESSORIES

A. Grab Bar:
   1. Basis-of-Design Product: Bobrick B-5806
   3. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
      a. Finish: Smooth, No. 4 finish (satin) on ends and slip-resistant texture in grip area.
   5. Configuration and Length:
      a. B-5806-36: Straight, Horizontal, 36 inches (914mm) long.
      b. B-5806-42: Straight, Horizontal, 42 inches (1067mm) long.
      c. B-5806-18: Straight, vertical, 18 inches (457mm) long.

B. Toilet Tissue Holders

   1. Non ADA Stalls: Kimberly Clark Double Roll Tissue Dispenser – Product Code 09021 - Smoke Grey
   2. ADA Stalls: Kimberly Clark Insight Coreless Double Roll Tissue Dispenser – Product Code KC-09604 – Smoke Grey

C. Paper Towel (Roll) Dispenser

   1. Kimberly Clark Insight Sanitouch Hard Roll Product code 9990 - Black

D. Foam-Soap Dispenser

   1. Kimberly – Clark Professional Cassette Skin Care Dispenser Product code 92145 - Black

E. Sanitary-Napkin Disposal Unit

F. Waste Receptacle – Free Standing

   1. Rubbermaid Slim Jim Wash Container Product Code RCP 3540 - Gray

G. Shelving – Wall Mounted

H. Coat Hooks – on inside of toilet stall door

I. Mop Sink – Refer to 22 30 00
J. Mop Rack

K. Hose and Reel

L. Electric Hand Dryer
   1. Install on in each bathroom – Dyson Airblade V Series Model AB12 Sprayed Nickel

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 10 28 00
SECTION 10 43 13 - DEFIBRILLATOR CABINETS

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements:
   1. Provide automatic external defibrillators (AED) cabinets and devices in all new buildings.
   2. Locate one (1) AED cabinet and device in the main lobby of each new building. Coordinate all locations with the University Fire and Life Safety Officer.

PART 2 - PRODUCTS

2.1 AED CABINET

A. Cabinet Type: Semi-Recessed cabinet with strobe and alarm.
   1. Basis-of-Design Product: Modern Metal Products; #147SR3-14R-38

B. Alarm:
   1. Visual Alarm:
      a. Color: Red
      b. Alarm activates and deactivates the strobe.
   2. Audio Alarm:
      a. Speaker rated to transmit a siren sound of 85-120dB
      b. Alarm Circuitry: Activated upon opening cabinet door, deactivated after 30 seconds.
   3. Accessories
      a. Combination Pad/Battery Pack

C. Power Requirements for Alarm Board, Siren and LED:
   1. Provide a dedicated 120V, 20A duplex receptacle.

D. Wiring:
   1. Provide a 22 gauge, four conductor stranded cable routed from the AED enclosure to the nearest Security Control Panel. Coordinate with the University Electronic Security for terminations on both ends. Provide external relay connection to the University Police.

2.2 AUTOMATED EXTERNAL DEFIBRILLATORS (AEDs)

A. Basis-of-Design Product: HeartSine Technologies, Ltd; Samaritan PAD (Public Access Defibrillator); #SAM300P-37

B. Software:
   1. Basis-of-Design Product: HeartSine Samaritan PAD Saver EVO Date Review and Management Software; PAD-ACC-01

C. Accessories:
   1. Basis-of-Design Product: Carrying Case; #PAD-BAG-01

2.3 AED SIGNAGE

A. 3D Triangular Wall Signs:
   1. Basis-of-Design Product: HeartStation AED Signs; #TSS
PART 3 - EXECUTION

3.1 INSTALLATION

A. AED cabinets: Fasten cabinets to structure, square and plumb. Mount cabinet at 48” to center of door handle from finished floor.

B. AED’s: Provide one AED installed in each AED cabinet location.

END OF SECTION 10 43 13
SECTION 10 44 00 - FIRE PROTECTION SPECIALTIES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Fire Extinguishers: Provide in accordance with NFPA 10.

PART 2 - PRODUCTS

2.1 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS:

A. Multipurpose dry-chemical type, manufacturer's standard container: 4-A:60-B:C, 10-lb.

B. Other types: Not permitted, except if approved by the University Fire and Life Safety Officer, through the University Project Manager.

2.2 FIRE PROTECTION CABINET:

A. Type and Size: For indicated fire extinguisher.

B. Door Type: Solid with vertical window.

C. Door Glazing: Acrylic sheet, glass not permitted.

D. Accessories: Door locks not permitted unless approved by the University Fire and Life Safety Officer, through the University Project Manager.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting:

1. Locations: As approved by the University Fire and Life Safety Officer through the University Project Manager.

2. Mounting Height: 48” to center of door handle from finished floor.

3. Accessibility: Comply with accessibility requirements for both approach and reach.

END OF SECTION 10 44 00
SECTION 10 55 00 - POSTAL SPECIALTIES

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
1. Provide a Mail Center that is rear loading and accessible on a public side via a lock. Provide slot(s) to put 8 ½” x 11” campus mailing envelopes on public side.
2. Include multiple central mail drops.
3. Include sleeves and locking cabinets.
4. Work with the University Mailing Services and the University Project Manager for exact Project needs.
5. Refer to Part 4 for annotated photograph of typical Mail Center as an example of design requirements.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)
SECTION 11 00 00 - EQUIPMENT

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide drains at all dock levelers.
   2. Fixed and Movable Equipment:
      a. Fixed equipment shall generally be furnished and installed by the General Contractor as part of the construction contract.

PART 2 - PRODUCTS

2.1 ICE FLAKER

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ice-O-Matic; EF-250-A-32S or a comparable product by one of the following:
   2. Scotsman.

B. Free Standing Ice Flaker Unit
   1. Size: Approximately 32 inches wide, 41 inches high, 28 inches deep.
   2. Storage Capacity: Minimum 140 lb. self-contained insulated storage bin.
   3. Production Capacity: Minimum 400 lbs. of ice per 24 hour period at ambient room air temperature of 70 deg F and a water inlet temperature of 50 deg F.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 11 00 00
SECTION 11 24 23 - FACADE ACCESS EQUIPMENT

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide façade access equipment for all buildings taller than 3 stories and/or where portions of the façade are not accessible from the ground or a roof below.
   2. Provide fall-protection system at all roofs not provided with a protected edge.
   3. Provide a complete system of davit pedestals, davit sockets, davit arms, and tie-back anchors of sufficient number and location to provide full building façade maintenance utilizing either a stage drop or boson’s chair drop suspended from outrigger beams.

B. Performance Requirements:
   1. Contractor to provide delegated design and system engineering including Operation Procedure Outline Sheet (OPUS).

1.2 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with applicable codes and the following OSHA regulations:
      a. 1910.28, Subpart D (Walking and Working Surfaces).
      b. 1910.66 Subpart F (Powered Platforms for building maintenance).
      c. Appendix C to 1910.66 Subpart F (Personal Fall Arrest Systems, Section I - Mandatory).
      d. 1926.50 Subpart M (Fall Protection).
      e. “OSHA Ruling on Window Cleaning by Boson’s Chair”, Memorandum (March 12, 1991) to Regional Administrators from P.K. Clark, Director, Directorate of Compliance Programs.
   2. ASME A120.1-2001, Safety Requirements for Powered Platforms for Building Maintenance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. Pro-Bel Group.
   2. Spider, a division of SafeWorks, LLC.
   3. Tractel Group.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 11 24 23
SECTION 11 53 00 - LABORATORY EQUIPMENT

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:

1. Chemical Fume Hoods

a. Acceptable types of fume hoods include conventional with variable air volume control. Unacceptable types include conventional with constant volume and auxiliary air.

b. Chemical fume hood exhaust applications must be considered as an entire system that includes both supply air and exhaust air needs. Consider the following issues to be applied to all retrofit fume hood applications, not on a select basis:
   1) Ventilation air for fume hood make-up must be provided to the laboratory space. The make-up air should not be recirculated space air and should be 100% outside air. The laboratory environment must be under negative pressure, at about a 90% airflow ratio.
   2) The preferred fume hood superstructure should be a variable air volume type configuration (constant face velocity with varying sash height) with a vertical sash and balanced and adjusted to meet the required fpm for the specified equipment. The hood manufacturer should be similar to Kewaunee and ideally a 4 foot nominal length (700 cfm), with specified optional services; such as vacuum or natural gas -- if necessary. The hood must include a low velocity alarm, similar to Kewaunee No. 839.
   3) The exhaust fan should be a utility set specifically designed for the proposed application, similar to New York Blower GP series fan (airfoil wheel). Special fan coatings and dark resistant construction are not necessary unless out-of-the-ordinary circumstances are present. The fan should include a weather cover, belt guard, spring vibration isolators, housing drain with cap, bolted cleanout door with gasket, TEFC motor with fixed pitch belt drive. Refer to 23 05 93 – Testing, Adjusting, and Balancing for HVAC.
   4) The exhaust fan must be labeled per the University Equipment Identification Number Standards. Exhaust fan will be fed from a dedicated electrical circuit.
   5) The exhaust fan must be provided with an up-blast discharge with stack termination at a minimum of 10 feet above the roof. The stack must be supported with an adequate framing structure and the stack must be connected to the exhaust fan with a flexible connector. The exhaust stack exit velocity must be about 3,000 fpm (or as required by wind wake analysis) which is achieved by using a discharge cone or transition fitting to increase the velocity. The stack diameter should be full sized until the termination cone.
   6) The fume hood exhaust riser will require a leakage test per SMACNA standards at the specified negative pressure. In most cases, the duct riser will be galvanized steel, spiral seam construction - use stainless steel only if required by special circumstances. The ductwork fittings must be sealed air tight per welded seams or some other suitable means. Adjustable gore fittings are not acceptable for fume hood applications.
   7) Fume hoods using boiling acids need to operate as constant volume fume hoods, where constant maintained flow is required at all times to prevent condensation in the ductwork. The duct work and exhaust terminal will require a special coating or material to prevent rusting and premature failure of the system.

c. Other types of exhaust devices such as canopy hoods, storage cabinets, slot hoods, snorkels, etc. are generally not accepted as substitutes for fume hoods.

d. Design and installation of fume hoods is strictly controlled according to the following procedures:
1) User identifies to the University Project Manager requirements for fume hoods which include types, size, number, and list of chemicals and compatibilities.

2) The University Project Manager submits requirements and chemical list to the University Environmental Health and Safety (EHS) for classification of hood. Hood classification identifies acceptable uses for the fume hood and required face velocity.

3) The Classification and chemical list is submitted to mechanical engineer to use in designing the exhaust duct and fan system and selection of suitable materials.

e. Fume hoods require outside air makeup through the central system or with dedicated HVAC systems. Fume hood exhaust systems shall not be connected to general building exhaust systems. However, exhaust systems dedicated to laboratory where hood is located can be connected to hood exhaust.

f. All fume hoods shall have face velocity audible and visual alarms.

g. Other standards for the exhaust system, ductwork, air balance, controls and utilities are identified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC, Section 23 09 00 – Instrumentation and Control for HVAC and Section 23 09 93 – Sequence of Operations for HVAC Controls.

h. Provide third party validation and certification that fume hood complies with ASHRAE 110 as installed.

i. Coordinate required fpm per use in accordance with the manufacturer’s recommendations with the University EHS through the University Project Manager.

2. Biological Safety Cabinets

a. Biological safety cabinets and fume hoods cannot be connected with common ductwork or fans. Biological safety cabinets will be fed from a dedicated electrical circuit.

b. Contact the University EHS through the University Project Manager for specifications.

c. Provide third party validation and certification that biological safety cabinet complies with NSF Standard 49 as installed. Certify cabinet during commissioning by NSF certified individual.


e. BSCs may be recirculating (Class II, Type A) or exhausted by canopy- or thimble-connection (Class II, Type A2) or hard-ducted Class II, Type B1 or B2, dependent upon work to be conducted and risk assessment.

f. Provide Biological Safety Cabinet appropriate for the use being performed.

3. Chemical Storage Cabinets:

a. Provide sufficient storage cabinets or space in accordance with anticipated user needs.

b. Vent corrosive liquid storage cabinets under fume hoods or free standing storage cabinets directly into exhaust systems. Do not provide cabinet fans. Typical exhaust rates should be 50 cfm.

c. Per NFPA 30, do not vent flammable liquid storage cabinets. Coordinate any variance with the Authority Having Jurisdiction (AHJ).

d. Provide adequate space in room layout for storage cabinets.

e. Provide storage equipment appropriate to the use being performed.

4. Sterilizing Equipment:

a. Sterilizers can be provided with new steam generators supplied with DI water for clean steam. Power plant steam should be used as primary energy source. Plant steam can also be used with DI water-to-steam heat exchangers. It must be verified that adequate plant steam is available for specified sterilizer.

b. Sterilizers should be specified based upon the users required operational temperature.

c. Contractor shall notify the University Project Manager to set up service schedule for the sterilizing equipment.

d. Adequate exhaust and ventilation should be supplied to maintain sterilizer specifications for temperatures in space provided for installation.

e. Adequate space of no less than 2’ clearance on all sides and back of unit for maintenance and repairs shall be provided.
5. Coordinate with the University EHS through the University Project Manager for waste water pretreatment requirements.
6. Refer to 23 60 00 – Laboratory Piping Systems for venting requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manifolded Hoods: Subject to compliance with requirements, provide products by the following:
   2. Hamilton.

B. Biological Safety Cabinets: Available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Baker
   2. Nuaire

C. Washers and Autoclaves: Subject to compliance with requirements, provide products by the following:
   1. Bellimed (Preferred)
   2. Tuttnauer

PART 3 - EXECUTION

3.1 COMMISSIONING

A. The University will hire a third party commissioning agent. The Architect, Engineer, and Contractor are to coordinate with the Commissioning Agent.

3.2 ADJUSTING

A. Complete testing and balancing prior to commissioning. See 23 05 93 – Testing, Adjusting, and Balancing for HVAC.

3.3 CLEANING

A. Test, clean, and certify all equipment.

END OF SECTION 11 53 00
SECTION 12 20 00 - WINDOW TREATMENTS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Provide blinds and shades as required for light control and room privacy.
   2. Do not provide drapery unless approved by the University Project Manager.
   3. Provide blackout drapes to control light in rooms where projectors are provided.
   4. Where window treatments are required in laboratories, provide bleach resistant material without perforations. Cloth, mesh, or other absorbing materials are prohibited. Window treatments will be sprayed with disinfectant for cleaning purposes.

PART 2 - PRODUCTS

2.1 HORIZONTAL LOUVER BLINDS

A. Manufacturers: Subject to compliance with requirements provide products from one of the following:
   2. Levolor Contract; a Newell Rubbermaid company.

B. Slat Material: Aluminum.

C. Slat Width: 1 inch.

D. Operating Mechanisms: Wand-type slat tilter; cord lift control.

E. Tilt: Full.

2.2 ROLLER WINDOW SHADES

A. Manufacturers:
   1. Draper Inc.
   2. MechoShade Systems, Inc.

B. Operation: Manual, chain-and-clutch mechanism with spring lift-assist mechanism for shadebands that weigh more than 10 lb.

C. Shadeband Materials:
   1. Light-Filtering Fabric: For sun control.
   2. Light-Blocking Fabric: For blackout shades.

2.3 WINDOW FILM

A. Spatter-coated film manufactured by charged metal process with abrasion resistant coating. Dyes or pigments are not acceptable.

B. Color: Smoke and gray. Silver and bronze not acceptable except to match existing films.

C. Shading coefficient: Not more than 0.65.
D. Warranty: Replacement warranty for 5 years covering defects including, but not limited to, cracking, crazing, fading, peeling and reduction in all solar properties.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 12 20 00
SECTION 12 35 53 - LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. In existing buildings, match new casework to existing casework.
   2. Do not use wood casework where water and/or chemicals will be used.
   3. Provide side- and back-splashes at all laboratory countertops.
   4. Acceptable Casework Types:
      b. Metal.
      c. Solid-phenolic.
      d. Wood.
   5. Acceptable Countertop Types:
      a. Stainless steel.
      b. Epoxy resin.
      c. Laminate plastic.

PART 2 - PRODUCTS

2.1 CASEWORK

A. Manufacturers:
   1. Plastic-Laminate-Clad Casework: Subject to compliance with requirements, provide products by one of the following:
      a. Case Systems Inc.
      b. Fisher Hamilton, L.L.C
      c. LSI Corporation of America; a Sagus International company.
      d. TMI Systems Design Corporation.
   2. Metal Casework:
      a. Beco Lab.
      b. Fisher Hamilton, L.L.C.
      d. Mott Manufacturing Ltd.
   3. Solid-Phenolic Casework:
      a. Lab Resin.
      b. NuLab Furniture Corporation.
      c. Trespa North America
      d. Young Group, Ltd.

2.2 COUNTERTOPS

A. Stainless steel:
   1. Material: Type 316, 0.0625 inch thick (16 ga.) minimum with 0.0781 inch thick (14 ga.) minimum reinforcing channels.
   2. Edge Treatment: Minimum 3/16 inch deep die-formed marine edge; straight edges forming 1-1/4 inch tall face with minimum 1/2 inch bottom return.
   4. Seams and joints: Fully welded, ground smooth and polished to match adjacent surfaces.
   5. Sinks: Integral with top; fully-welded, ground smooth and polished to match adjacent surfaces.
   6. Sound deaden underside of all tops and sinks.
B. Epoxy resin: Fabricate with raised marine type edge and drip grooves around sinks and along front edge.
   1. Manufacturers:
      a. The Durcon Company.
      b. Epoxyn Products.
      c. Kemresin.
      d. Laboratory Tops, Inc.
   2. Sink: Integral with top.

C. Plastic laminate: Acid resistant.
   1. Core Material: Minimum 45 pcf particleboard except provide exterior grade, moisture-resistant, plywood at countertops with sinks.
   2. Edges: PVC edge treatment applied with hot melt adhesive; build to 1-1/4 inch thick at perimeter of countertop.
   3. Sink: Stainless Steel, Type 316 or Epoxy Resin under mount sink. Surface mounted sinks are prohibited.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 12 35 53
SECTION 12 46 00 - FURNISHING ACCESSORIES

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 CLOCKS

A. Wall Clocks:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Electric Time Clock
      b. Canterbury International
   2. Round, surface mounted, battery operated.
   3. Size: 12 inch diameter
   4. Finish: Black anodized aluminum housing
   5. Color: White clock face, black numbers

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 12 46 00
SECTION 12 48 00 - RUGS AND MATS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Entrance Floor Mats and Walk-off Carpets: Select type that will not hinder door operation; provide as part of construction contract; type and location to be approved by the University Environmental Health and Safety (EHS) through the University Project Manager.

PART 2 - PRODUCTS

2.1 ENTRANCE FLOOR MATS

A. Roll-up, Aluminum-Rail Hinged Mats: Continuous vinyl cushions.
   1. Tread Inserts: Level-cut, nylon-pile carpet.

B. Carpet-Type Mats: Nylon.

2.2 ENTRANCE FLOOR GRILLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Balco, Inc.
   2. C/S Group.
   3. Reese Enterprises, Inc.

B. Aluminum Floor Grilles:
   2. Tread Rail Top Surface: Carpet insert.

C. Frame: Same material and finish as foot grille.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 12 48 00
SECTION 12 61 00 - FIXED AUDIENCE SEATING

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, provide products from one of the followings:
      1. Hussey Seating Company.
      2. Irwin Seating Company.
      3. KI, Inc.
      4. Seating Concepts, LLC.

2.2 MATERIALS
   A. Fabric: 100 percent nylon or wool with flame-retardant treatment.

2.3 FIXED AUDIENCE SEATING
   A. Fixed Audience Seating: At a minimum, provide seating that complies with the following. Upgraded finishes are acceptable as reviewed and approved on a project specific basis by the University Project Manager.

   B. Chair Mounting: Provide the following as appropriate to installation.
      1. Standards: Floor or riser attached; steel or cast iron standards.
      2. Beam: Mounted on floor or riser-attached pedestals.
      3. Pedestal: Floor-attached.
      4. End Panels.

   C. Fabric Upholstered Chairs:
         a. Rear Panel: Molded plastic.
      2. Seats: Two part.
         a. Seat Bottom: Steel sheet seat pan.

   D. Back Height: Standard style.

   E. Back Pitch: Fixed.

   F. Chair Seat Hinges: Self-rising, spring actuated.

   G. Armrests: Plastic.

   H. Power and Data Service Package: Power receptacles and data ports to each seat location.

   I. Tablet Arms: Standard-size, foldaway tablet arm with plastic-laminate writing surface.

   J. Accessible Seating: Provide.

2.4 LECTURE-HALL TABLES
   A. Supports: Attached to floor.
B. Table Top: Plastic laminate on medium-density fiberboard.

C. Modesty Panels: Partial-height panels.

D. Power and Data Service Package: Power receptacles and data ports in table top at each seat location.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 12 61 00
SECTION 12 93 00 - SITE FURNISHINGS

PART 1 - GENERAL (Not Applicable)

PART 2 - PRODUCTS

2.1 FURNISHINGS

A. Benches:
   1. Landscape Forms, Inc.; Scarborough, 72” backed and/or backless with horizontal seat strap
      a. Color: “Stormcloud” RAL 7022

B. Tables:
   1. Landscape Forms, Inc.; Catena table, 30” round, no hole, with embedded support base
      a. Color: “Stormcloud” RAL 7022
   2. Landscape Forms, Inc.; Catena table, 36” round, no hole, with embedded support base
      a. Color: “Stormcloud” RAL 7022

C. Chairs:
   1. Landscape Forms, Inc.; Scarborough, 24” backed and/or backless with horizontal seat strap
      a. Color: “Stormcloud” RAL 7022

D. Receptacles:
   1. Litter Receptacle: Landscape Forms, Inc.; Scarborough, side opening litter receptacle, vertical strap
      a. Color: “Stormcloud” RAL 7022
   2. Recycling Receptacle: Landscape Forms, Inc.; Scarborough, single use, side opening recycling receptacle, vertical strap
      a. Color: “Stormcloud” RAL 7022
      b. Signage: Recycling Symbol

E. Bicycle Racks:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide BRP Enterprises, Inc. WA-207-SM-MF or comparable product.
      a. Color: “Stormcloud” RAL 7022
      b. Paint 3 coats, smooth glossy finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification Of Conditions:
   1. Examine areas and conditions under which the Work of this Section will be performed. Report unsatisfactory or questionable conditions to the Contractor.
   2. Do not proceed with the Work until unsatisfactory conditions have been corrected. Commencement of work implies acceptance of all area and conditions.

3.2 INSTALLATION, GENERAL

A. Placement and Mounting:
   1. Protect pavement from harm including scratching or cracking due to furnishings placement operations. Do not drop or drag furnishings on pavement.
3.3 TESTING CLEANING AND CERTIFICATION

A. Remove protective covering.

B. Clean exposed surfaces with clean water. Use cleaner and procedures recommended by manufacturer and fabricator. Do not use wire brushes, metal scrapers or acids. Protect adjacent surfaces from damage during cleaning operations.

C. Repair: After cleaning, examine work and repair unacceptable conditions. Replace defective, broken, permanently stained, or damaged units. Repair unfilled or defective joints.

END OF SECTION 12 93 00
SECTION 13 11 00 - SWIMMING POOLS

PART 1 - GENERAL

1.1 REFERENCES
1. Colorado Department of Health Swimming Pool Regulations and Standards.
2. Joint Committee on Bathing Places, Conferences of State Sanitary Engineers and the Engineering Section of the American Public Health Association.

1.2 QUALITY ASSURANCE

A. Contractor or subcontractor must have experience with a minimum of 3 similar aquatic facilities.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 13 11 00
SECTION 13 20 00 - SPECIAL PURPOSE ROOMS

PART 1 - GENERAL

1.1 SYSTEM REQUIREMENTS

A. Design Requirements:

1. Hyperbaric and Hypobaric Chambers:
   a. Conform to NFPA 99.

2. Dark Rooms - Photographic:
   a. Conform to OSHA 29CFR1910.94 and .100

3. Spray Painting Rooms - Booths:

4. Animal Quarters:
   a. Conform to USDA animal care.
   b. Shall be reviewed by Director of Lab Animal Resources through the University Project Manager.
   c. Conform to the Guide for the Care and Use of Laboratory Animals. Published by the Institute of Laboratory Animals Resources (ILAR) of the National Research Council

5. Biohazard Locations and Containment Facilities:
   a. Conform to the University BL3 construction standard (campus standard), that can be obtained through the University Project Manager, and CDC/NIH Biosafety Guidelines in microbiological and biomedical laboratories guidelines.

6. Food Preparation and Serving Areas:

7. Chemical Storage Rooms:
   b. Rooms shall be suitable to type of materials stored (NFPA-45[1991]) in regards to specific temperature, absence of light, humidity or avoidance of any moisture, explosive conditions, ventilation, blast walls, etc.

8. Semiconductor Fabrication Facilities:
   a. Conform to IFC Article 51.

9. Pesticide Storage:
   a. Conform to IFC Articles 47, 80 and 86 and NFPA-43D.
   b. Conform to Colorado Department of Health "Standards and Regulations for Any Gathering Places".

10. Chemical Laboratories:
    a. Conform to NFPA-45 (and 99 if medical/veterinary medicine activities are involved), OSHA 29CFR1910.1450, applicable OSHA standards if an OSHA regulated substance is involved.

11. Welding Shops:

12. Compressed Gas Cylinder Storage:

13. Battery Rooms:
    a. Conform to OSHA 29CFR1910.178(g), 29CFR1926.441 and NEC.

14. Child Care and Pre-school:

15. Controlled Environmental Rooms and Cold Rooms:
    a. Maintain temperature and humidity set-points without operation at full capacity more than 80 percent of the time under the specified ambient conditions.
b. Recess floor slab to align the top of finished floor in the controlled environment room with the top finished floor outside the room. Ramps into the unit are to be avoided where possible.
c. Ceiling systems are prohibited.
d. Coordinate with the University Project Manager to determine the use of the room, quantity of occupants, and duration of use.

B. Performance Requirements
   1. Controlled Environmental Rooms and Cold Rooms:
      a. Maximum horizontal temperature uniformity between any two (2) points shall be no more than plus or minus 1.0 degrees C from the set-point.

1.2 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant systems that have been properly charged per manufacturer’s instructions, record the final amount of oil and refrigerant charge in operation and maintenance manuals and on or near the data plate of the unit.

PART 2 - PRODUCTS

2.1 CONTROLLED ENVIRONMENTAL ROOM

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products from one of the following:
   1. Environmental Growth Chambers (preferred)
   2. LUWA/Environmental Specialties, Inc.
   3. Harris Environmental Systems, Inc.

B. Equipment:
   1. Refrigeration System:
      a. Design Evaporator and Condensing units to operate continuously, providing cooling output on demand proportioning basis in relation to desired temperature control point.
      b. Refrigerant: CFC’s are prohibited. Coordinate with LEED requirements.
      c. Condensing Unit:
         1) Seamless steel, cleanable shell and tube or shell and coil, heavy-duty water-cooled type (using refrigerants) with removable, interchangeable cast iron water heads and 1/2 inch diameter copper tubing with aluminum fins.
         2) Condenser shall be designed for plant-chilled water at 45 degrees F supply, 90 degrees F return.
         3) Provide control valve as driven by compressor refrigerant head pressure sensor.
      d. Compressor: Reciprocating serviceable, semi-hermetic or hermetic type, with suction and discharge stop valves, automatically reversible oil pump and oil pressure gauge (for hermetic type pump), dual pressure switches, compressor over-temperature protection and a fused control circuit, designed for continuous operation. Locate on top of the Controlled Environmental Room where possible.
      e. Control System: Provide digital touch screen panel type. Network controller on the BAS or building network for temperature and other controlled variables including, but not limited to, monitoring, trending, and alarming.

C. Materials
   1. GALVANIZED STEEL SHEET: Hot-dip zinc-coated steel sheet, G90 coating, stretcher-leveled flatness per ASTM A 924. Type and surface preparation to be as determined by manufacturer to suit intended purpose.
   2. STAINLESS STEEL SHEET: Type 302/304 stretcher leveled, cold-rolled, complying with ASTM A 167 and A 480. Tempered, edge condition and heat treatment to be as determined by manufacturer to suit intended purpose. Finish: Number 4 general purpose polished.
3. **ALUMINUM SHEET**: Aluminum or aluminum alloy sheet complying with ASTM B 209. Alloy, temper, heat treatment and surface preparation to be determined by manufacturer to suit intended purpose.

4. **URETHANE FOAM INSULATION**: Foam shall have a density of 2.2 pcf. Thermal conductivity factor "K" shall not exceed 0.118 (BTU)(inch)/(hour)(square foot)(degree F). The U-value overall heat transfer coefficient shall not exceed 0.029 (BTU)/(square foot)(hour)(degree F). The R-value shall be 34.

5. **HEAT-TREATED FLOAT GLASS**: ASTM C 1048, Condition A (uncoated surfaces), Type I (transparent, flat), Class 1 (clear), Quality q3 (glazing select).

D. **Accessories**
   1. **Lights**:
      a. Basis of Design: Subject to compliance with requirements, provide Dialite Durosite Series LPK LED Linear Fixture or comparable.

E. **Fabrication**
   1. **Panel Construction**
      a. **Wall and Ceiling Face Sheets**.
         1) Unexposed Exterior Walls: Galvanized Steel Sheet.
            a) Minimum 24 gauge thick.
            b) Surface: Smooth.
         2) Exposed Exterior Walls: Stainless Steel Sheet.
            a) Minimum 22 gauge thick.
            b) Surface: Smooth.
         3) Interior Walls: Aluminum Sheet.
            a) Minimum 0.040 inch thick.
            b) Surface: Smooth.
            c) Color: White.
      b. **Floor Panel Bottom Layer**: Minimum No. 14 gauge thick galvanized steel sheet.
      c. **Floor Panel Top Layer**: Minimum No. 16 gauge thick galvanized steel sheet.
      d. **Core**: Foamed-in-place insulation. Do not use wood, metal, fiberglass or plastic forming members.
      e. **Panel Dimensions**:
         1) Width: Multiples of 11 1/2 inches.
   2. **Doors**: Provide solid doors with view window.
   3. **Electrical**: Provide a minimum of two (2) 120V, 20A circuits to serve the duplex receptacles inside the room.

F. **Seamless Vinyl Flooring**:
   1. Basis of Design: Subject to compliance with requirements, provide Altro Floors or comparable.

G. **Controlled Environment Room Schedule**

<table>
<thead>
<tr>
<th>Room Designation</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Room</td>
<td>4°C +/- 1°C</td>
</tr>
<tr>
<td>Controlled Environmental Room</td>
<td>4°C to 37°C +/- 1°C</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION (Not Applicable)

**END OF SECTION 13 20 00**
SECTION 14 20 00 - ELEVATORS

PART 1 - GENERAL

1.1 The following guidelines establish standards for the University of Colorado Denver | Anschutz Campus elevator designs. These are to be used as guidelines as to the selection of number, type and speed of elevators. Final design should be based upon calculations that support the performance criteria within this section.

1.2 DESIGN REQUIREMENTS

A. Elevator Cab Numbering: Refer to Part 1.6, C

1.3 PERFORMANCE CRITERIA

A. Elevator calculations will be completed based upon a traditional two button dispatching system over a peak five minute two-way traffic calculation. At a minimum the system design performance will meet the following criteria:
   1. Average Interval: 35 seconds
   2. Handling Capacity: 14% of building population
   3. Maximum 80% platform utilization

1.4 CIRCULATION PLANNING

A. Coordinate elevator performance analysis with the following circulation requirements:
   1. Public elevators will be located in direct walking path that is visible from public entries to the building. Elevators will be located near or adjacent public circulation stairs. Elevator lobbies will be designed to meet fire protection standards.
   2. Service elevators will be located to facilitate building function. Projects with more than four floors, dedicated laboratory spaces and/or kitchen facilities will have a separate service elevator(s).

1.5 SYSTEM MINIMUM REQUIREMENTS

A. Elevator Type, Quantity and Configuration:
   1. Design Requirements
      a. Provide a hydraulic elevator for up to four landings, minimum speed of 125 fpm, maximum speed of 150 fpm. Speed will not vary by more than 10%.
      b. Provide machine room less or geared elevators for up to fifteen landings, minimum speed of 200 fpm, maximum speed of 450 fpm. Speed will not vary by more than 3%.
      c. Provide gearless elevators above fifteen landings, minimum speed of 500 fpm. Speed will not vary by more than 3%.
      d. Final selection will be based upon compliance to the performance criteria, as well as maintainability and service for the life of the building.
      e. Machine-room-less elevators can only be used if diagnostic equipment stipulated below will be provided to the University.
      f. Provide a second elevator where feasible to be used in cases of maintenance and unscheduled service outages.
   2. Performance times below will be utilized for analysis and specifications.
      a. Hydraulic
      b. Floor to Floor performance times: (based on 12’-0” floor height)
ELEVATORS

1.6 SUBMITTALS

A. Product Approval
1. Include machine room, hoistway, cab and fixture layouts engineered specifically for the project.

B. Product Documentation:
1. Include project specific Operating and Maintenance Manuals as well as Wiring Diagrams submitted in both hard copy and on CD Disk.
2. Include recommended inspection, preventative maintenance, lubrication and adjustment schedules and instructions, identification of and sources for any special or unusual tools or materials, a list and specifications for each recommended lubricant and where, when and how each is to be used.
and any other information appropriate for operation, inspection, service and maintenance for optimum performance.

C. Minimum Turnover Documents
   1. Records: All Product Documentation, completed punch list, inspection and correction records. Acceptance inspection will be by an inspector Certified as meeting the requirements of ASME QEI-1 as required by ANSI/ASME A17.1.
   2. Service Keys: Three (3) sets of keys.
   3. Diagnostic Test Equipment with Instructions: Necessary diagnostic test devices with complete documentation and supporting information for effective use of and interpretation of data and troubleshooting and adjustment of the systems.

1.7 WARRANTY AND MAINTENANCE

A. Warranty: Warrant equipment material and workmanship for one year from date of acceptance of substantial completion.

B. Specifications shall include a preventative maintenance schedule consistent with the warranty period.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Control System
   1. Maintainable control with common features such as Independent Service, Fire Fighters Service, and Emergency Power Operation.
   2. Provide a microprocessor-based controller installation that is able to be maintained by any licensed elevator maintenance company without the need to purchase or lease diagnostic devices or special tools or software from the original equipment manufacturer.
      a. Controller shall include diagnostic capability to monitor, store and recall elevator malfunctions. Controller or provided diagnostic tool shall have the ability to complete all code mandated tests. Controller shall have on-board, or provided diagnostic tool, shall enable field programmable features such as adjustable door times and other industry standard and appropriate features and adjustments. Controller or provided diagnostic tool shall retain system errors and trouble codes for use in diagnosing trouble calls.
      b. Manufacturers of elevator control systems may provide their own controllers as long as they include full diagnostic tools over the lifetime of the building without restrictions, recalibrations, or lease agreements.
   3. Provide security interface with building security system. Access shall be dictated by building security access; elevator contractor shall provide necessary interfaces for access and tracking of floor(s) selected. Interface shall be provided via serial interface link.

B. Cab Design
   1. Cabs will be constructed of a steel shell with removable interior panels with a finish selected by the architects.
   2. Cab fronts and doors will be, at a minimum, brushed stainless steel.
   3. Cab ceiling will be, at a minimum, a drop ceiling finished in brushed stainless steel with LED lamps.
   4. Cab lights and fan will shut off after demand extends beyond five minutes.

C. Fixtures
   1. Provide vandal-resistant buttons, indicators and panels. Provide LED indicator lights with a long life and ease of maintenance design.
   2. Include one car operation panel adjacent each opening and one hall push button station per floor for every two passenger elevators.
3. Provide hall lanterns on all passenger elevators.
4. Provide car direction signs for all single service elevators, hall lanterns for groups of service elevators.
5. Car operating fixture shall include a field programmable, hands free, two-way communication device. Device shall be isolated from high voltage to eliminate noise on the line. Call out initiation shall be by push button only. Device shall not activate cab alarm bell.
6. All fixture key switches shall meet the campus standards.
   a. Provide small format (7pin) interchangeable cores.
   b. Key all elevators alike. Coordinate with the University Facility Operations requirements.
7. Provide one riser of hall push button stations per two elevators. Stations shall be flush mounted faceplates, with illuminating pushbuttons for each direction of travel which illuminate to indicate call registration. Include approved engraved message and pictorial representation prohibiting use of elevator during fire or other emergency situation as part of faceplate. Pushbutton design shall match car operating panel pushbuttons.

D. Door Operators:
1. Design Requirements
   a. Closed-loop, high speed, heavy-duty master door operator type with a minimum of ½ horsepower motor. Operator will include on-board diagnostics and be capable of adjustable door times.

E. Car Guides
1. Provide slide guides for speeds less than 150 fpm or for heavy duty freight applications. Otherwise provide roller guides.

F. Car and Hoistway Entrance Finishes
1. Minimum of baked enamel or brushed stainless steel as selected by the architect. Car and hoistway doors shall match.

G. Hydraulic Elevator:
1. Machine Room and Equipment
   a. Locate machine room at the lowest hoistway level directly adjacent to or as near as possible to the hoistway.
   b. Pump unit shall be a submersible pump with an electronic hydraulic valve.
   c. All associated piping and components shall be isolated to minimize transfer of noise to the building.
   d. Any hydraulic cylinder holes shall be cased with steel as required to maintain the hole. The cylinder will be protected with a PVC casing filled with Union-Gard.

H. Traction Elevator:
1. Machine Room and Equipment
   a. Locate machine within the hoistway, room directly above the top of the hoistway or adjacent at the bottom of the hoistway.
   b. The machine either be a permanent motor permanent magnet machine or a worm gear traction machine with an AC VVVF motor control.

I. Hoistway and Pit Equipment:
   a. Necessary mechanical equipment for operation of the elevator. The equipment will be installed according to manufacturer’s recommendations and properly field painted before acceptance.

J. Emergency Operation
1. Provide battery lowering for hydraulic elevators or single car operation on the emergency generator for traction elevators. Coordinate the necessity of a pre-transfer signal from the emergency generator to indicate power supply is changing from normal to emergency power, and back again. Signal shall provide a 20 second delay before the power source is changed.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation Requirements
1. Installation shall be completely coordinated between contractors without The University’s representatives’ involvement.
2. Installation shall be completed via manufacturer’s installation procedures.
3. Elevator machine room, hoistway and pit shall be painted prior to turnover to the University.
4. All equipment shall be properly cleaned after temporary construction use.

3.2 FIELD QUALITY CONTROL

A. Provide complete installation, testing and appropriate inspections and reports by trained and experienced professionals.
B. Repair or replace parts and/or materials that fail as a result of any testing.
C. Necessary maintenance documentation, including as-built wiring diagrams, shall be properly stored and posted in the machine room. Prior to final acceptance the University will receive the following:
   1. Four Operating and Maintenance Manuals
   2. Four sets of as-built wiring diagrams
   3. Four sets of parts catalogs
   4. A CD-ROM containing all of the necessary turnover documents
   5. Ten sets of keys
D. Provide coordination with and guarantee timetable and completion and acceptance dates to the University, with penalties as provided in the contract.

3.3 TEMPORARY USE

A. Temporary use of the elevator(s) will be permitted as an arrangement between contractor(s). The University shall receive a final installation that is fully warranted, free of defects and in compliance with the specifications.

END OF SECTION 14 20 00
SECTION 21 05 00 - FIRE SUPPRESSION

PART 1 - GENERAL

1.1 REFERENCES

A. Section 230000 - General Mechanical Provisions
B. Section 210553- Mechanical Identification

1.2 DESIGN REQUIREMENTS

A. Automatic Fire Sprinklers:
   1. Zone system according to location. Annunciate each zone at the building fire annunciator in accordance with NFPA regulations. Provide separate zones for each flow switch and each tamper switches.
   2. Install recessed sprinklers in 8-foot ceilings. Provide wire guards on sprinklers, which protrude beyond the ceiling and are lower than 8 feet. Wire guards may be painted.
   3. The type of sprinkler to be installed must be specified and approved no later than final design completion.
   4. Consult the University CBO, through the University Project Manager, for fire protection and life safety concerns.
   5. Supply all connections to the fire system from the domestic water system through a reduced pressure backflow prevention device.
   6. Provide fire sprinkler systems for every building. Provide sprinklers throughout the building. Discuss areas without sprinklers with the University Project Manager.

B. System Design:
   1. General:
      a. Base design on requirements of NFPA 13, including Appendices.
      b. Verify fire hydrant flow test according to NFPA 13 and NFPA 291. Use hydrant flow results for system design calculations.
      c. Base design of sprinkler system on hydraulic calculations for group and occupancy listed in NFPA 13. Include outside hose flows upon the same hazard as the building. No allowance will be made for inside hose station flows. Include a safety factor of 10 psi in hydraulic calculations.
      d. Room design method is not acceptable.
      e. Size flow velocity in underground water mains not to exceed 16 feet per second. Size velocity in above ground sprinkler systems not to exceed 20 feet per second
      f. Protect all areas of each facility with an automatic sprinkler system unless specifically waved by the University Project Manager.
      g. Provide a separate zone on each floor for buildings exceeding 3 floor levels including the basement.
   2. Wet Pipe Systems:
      a. Use wet pipe systems for the majority of system applications.
      b. Use electronic vane type water flow detectors except for the following:
         1) Alarm check valve assemblies may be used for systems installed in buildings if there is no approved fire alarm control panel installed and the system protects only one zone.
   3. Antifreeze Systems:
      a. Do not install antifreeze systems unless specifically approved in writing by the University Project Manager.
      b. If these systems are proposed, only use them for incidental areas susceptible to freezing, as required.
c. Determine the feasibility and advantages of using other approved methods for protection of piping against freezing.
d. Include procedure in specifications for flow testing antifreeze systems without reducing antifreeze concentration.

4. Dry Pipe Systems:
a. Provide dry pipe systems in areas susceptible to freezing. Dry pipe systems are preferred over antifreeze systems. Condensate collector drain valve shall be full-port ball valve type.
b. Maintain air pressure by a nitrogen system or automatic air compressor powered from a dedicated circuit supplied from the building emergency circuit, where available. Use of a reliable plant air supply, in lieu of or in addition to an air compressor, is acceptable.
c. Monitor piping for low air pressure.

5. Pre-action Systems:
a. Provide pre-action systems as directed by the University Project Manager.
b. Supervise pre-action piping by an approved method.
c. Electronically release pre-action valve assemblies through an approved releasing panel. Coordinate the panel with Division 26 work.
d. Activate pre-action valve by means of automatic fire detection with manual release capability.
e. Space automatic fire detection devices according to NFPA 72. Detection method shall be by one or more of the following, as determined by the Engineer on specific project requirements:
   1) Smoke Detectors
   2) Heat Detectors
   3) Loss of Air Pressure
   4) Manual
f. Coordinate system activation method and sequencing with Division 26. Sequence of operation for valve actuation shall follow one or a combination of the following as determined by the Engineer:
   1) Automatic Detector Signal
   2) Cross-zoned or verified Automatic Detector Signals
   3) Automatic Detector Signals and Loss of Air
   4) Manual

6. Deluge Systems:
a. Provide deluge valve assembly, including valve, trim packages, and actuation system approved by Factory Mutual, as a complete assembly.
b. Detection systems can be pilot line or electronic as determined by the Engineer.
c. Provide a dedicated air supply system if pneumatic detection is incorporated into the design.
d. Space hydraulic or pneumatic heat detectors spaced according to NFPA 13 and manufacturer’s requirements.
e. Space fire detection in accordance with NFPA 72.
f. Provide approved agent releasing panel if deluge valve actuation is by electronic means.

7. Exposure Protection Systems:
a. Provide exposure sprinkler system with an independent supply from the vertical or main riser, prior to any other sectional controls, with a supervised control valve and distinctive flow detection.
b. Control systems incorporating open sprinklers by the operation of detection devices designed for the specific application.

8. Standpipe Systems:
a. Design system as required by current State of Colorado approved version of the NFPA and IBC.
b. Locate hose valves within the building stairway enclosures with additional corridor locations as required, unless alternative locations are approved by the University Project Manager in writing.
c. Provide approved roof manifolds where required by current State of Colorado approved building codes or by the University CBO. Roof manifolds shall be 4 inches in diameter, with two 2-1/2-inch gated outlets. The interior control valve shall be operable from the roof location. Provide accessible manual drains and automatic drip.

d. Hydraulically calculate standpipe systems.

9. Elevator and Electrical Equipment:
   a. Comply with the requirements of ANSI A17.1 for the installation of sprinkler systems in elevator machine rooms and shafts.
   b. Where elevator equipment is provided with Phase I emergency service, provide sprinkler protection in the elevator shaft and elevator machine room. Sprinkler protection serving these areas shall be as follows.
      1) Provide 286 degree F. sprinkler with guards, in elevator machine rooms and hoistways.
      2) Provide control valve with tamper switch outside elevator machine rooms and shafts.
      3) Provide one smoke detector in the vicinity of each sprinkler for elevator recall. Coordinate between Divisions 21, 22, 23 and 26 for proper detector and sprinkler locations.
      4) Provide one 190-degree F. fixed temperature non-resetting heat detector adjacent to each sprinkler. Heat detectors shall automatically disconnect power to the elevator machinery and the elevator controller.
      5) Design elevator machine room and hoistway sprinkler system as a separate zone with its own valves, flow switch and tamper switch.
      6) Protect each bank of elevators and associated equipment rooms by an independent system unless determined otherwise by the Engineer and approved by the University Project Manager.
      7) Protect transformer rooms by a pre-action sprinkler system. Other systems may be approved on a case by case basis as determined by the Engineer and approved by the University Project Manager.

10. Protection for Mechanical Shafts:
   a. Sprinklers are required in all shafts where shaft construction or contents are combustible or where the shaft is accessible by personnel. Sprinklers are not required for shafts housing a single duct which occupies the entire area of the shaft.
   b. Install sprinklers in shafts accessible for inspection, maintenance, or repair and replacement.
   c. Place sprinklers at the top of all shafts requiring protection. Additional protection may be required if the shafts have offsets.

11. Protection for Shafts Housing Hazardous Exhaust System:
   a. Provide sprinklers for protection of all shafts serving a special hazard exhaust system. Coverage is not required if the shaft is dedicated to special hazard exhaust systems, and the shaft is not accessible by personnel and is of fire resistive non-combustible construction and ductwork is completely non-combustible.
   b. Consult the University Project Manager in all situations.
   c. Refer to the appropriate NFPA standards for the design of sprinkler systems for special hazard exhaust systems such as paint spray operations or cooking exhaust.

1.3 SUBMITTALS

A. Submittals for the following shall be made in accordance with Section 230000.
   1. Submit sample of each type and finish of sprinkler and escutcheon plate to be installed.
   2. Submit shop drawings showing all details as defined by NFPA 13. Show pipe routing and coordination of all building components.
   3. Submit hydraulic calculations including summary sheet, detailed work sheets, graph sheet, and water supply information as outlined in NFPA 13. Designer shall seal and sign hydraulic calculations, drawings, and work sheets.
5. Submit copies of Contractor’s Material and Test Certificates similar to those in NFPA 13.

1.4 QUALITY ASSURANCE

A. Design shall be performed by a NICET Level III or IV Technician, Registered Fire Protection Engineer, or Registered Professional Engineer with experience in fire protection design and registered for the design and installation for fire protection systems in the State of Colorado.

B. Installer shall have a minimum of five years of experience in the design and installation of automatic fire sprinkler systems and employ workmen experienced and skilled in this trade.

C. Installer shall have the capability of providing a full service maintenance, testing, and inspection program in accordance with NFPA standards and where applicable, be certified to perform these services.

D. Installer shall have an emergency service capability for response to emergency conditions and shall be capable of responding within four hours or receiving notification with 24 hour service capability.

E. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, Specifications of Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3.

F. Regulatory Requirements: Comply with the following codes:
   1. NFPA 13 - Standard for the installation of sprinkler System.
   2. FPA 14 - Standard for the Installation of Standpipe and Hose Systems.
   3. NFPA 24 - Installation of Private Fire Service Mains and their applications.
   5. UL Compliance: Fire protection system materials and components shall be Underwriter’s Laboratories listed and labeled for the application anticipated.
   7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Gate Valves:
      a. Nibco Inc.
      b. Mueller
      c. Grinnell
   2. Butterfly and Ball Valves:
      a. Mueller
      b. Victaulic
      c. Nibco Inc.
   3. Grooved Mechanical Couplings:
      a. Victaulic Company of America
      b. Gruvlok
      c. Or approved equal per Division 1 requirements.
   4. Sprinklers:
      a. Reliable
      b. Viking Corp.
      c. Grinnel
   5. Fire Protection Specialties:
      c. Guardian Fire Equipment, Inc.
6. Backflow Preventers:
   a. Febco
   b. Watts
   c. Hersey

7. Check Valves:
   a. Central Sprinkler Corp.
   b. Mueller
   c. Viking Corp

8. Fire Protection Specialty Valves (Dry, Pre-action, Deluge):
   a. Viking Corp.
   b. Viking
   c. Victaulic
   d. Reliable

9. Air Compressors:
   a. Emglo Products Corp.
   b. Gast
   c. Viking Corp.

10. Alarm, Flow, and Tamper Switches:
    a. Potter Electric Signal Corp.
    b. System Sensor
    c. Victaulic

11. Fire Department Connection:
    a. Croker
    b. Potter Roemer
    c. Elkhart
    d. Guardian Fire Equipment, Inc.

12. Inspector’s Test and Drain Module:
    a. Victaulic
    b. A.G.F.
    c. Grinnell/Gem

2.2 MATERIALS, GENERAL

A. Piping:
   1. Black steel pipe for wet pipe systems and standpipes. Hot dipped galvanized pipe for dry pipe, pre-action and deluge systems.
   2. Schedule 40 for pipe 2-inch and smaller and joined with threaded or cut grooved fittings.
   3. Schedule 10 for pipe sizes up to 5 inch and 0.134 inches for 6 inch pipe for pipe joined by welding or roll grooved fittings.
   4. Other pipe thickness is acceptable provided the pipe UL corrosion resistance ratio (CRR) exceeds 1.00. Schedule 40 black steel has a CRR of 1.0
   5. Fittings: Provide hot dipped galvanized fittings for dry pipe, pre-action, and deluge systems. Threaded fittings are preferred in architecturally exposed or sensitive areas.
   6. Do not use Copper pipe or fittings

B. General: Equipment shall bear the UL listing for the intended use.

C. Valves:
   1. General Requirements
      a. Suitable for a minimum of 175 psi. working pressure unless the project requirements demand higher pressures.
      b. Riser and Sectional Control Valves: Provide indicating type suitable for supervisory contact switch.

D. Check Valves:
   1. 1-1/2 inch and smaller: All bronze with screwed ends.
2. 1 inch and larger: Iron or brass body.
3. Alarm Check Valve: Same size as riser. Provide with a retarding device.

E. Miscellaneous Valves:
1. Ball Drip Valves: Brass with 1/2 inch NPT.
3. Gauge Assembly Valves: 1/4 inch globe or angle 3-way valves with screwed bonnet and renewable composition disc.
4. Combination Test/Drain Valve: UL listed approved.

F. Dry Pipe Valve:
1. Differential or latching differential type, sized by hydraulic calculations and supplied by pipe of equal or greater size.
2. Positive latching clapper.
3. Trim, accelerators, and exhaustors provided by same manufacturer as dry pipe valve.

G. Pre-action and Deluge Valves:
1. UL listed approved as a complete assembly, including valve, trim packages and actuation system.
2. Sized by hydraulic calculations and supplied by pipe of equal or greater size. Valve trim includes manual control/activation capability, drain and test provision with trim for automatic operation via a 24-volt solenoid.
3. Valve wired normally closed.

H. Solenoid Release Valves:
1. Specifically listed and approved for fire protection systems and compatible with pre-action valve and fire alarm control panel.

I. Gauges:
1. Water Pressure: Brass bourdon tube with 3-1/2 inch diameter case rated for 300 psi water pressure in 5 pound increments. Equip with 1/4-inch shut-off valve.
2. Air Pressure: Brass bourdon tube with 3-1/2 inch diameter case rated for 100 psi air pressure in 1 psi increments. Equip with 1/4-inch shut-off valve.

J. Fire Department Connections:
1. Siamese connection, double 2-1/2 inch clapper, swivel plugs, and chain, threads matching local fire district equipment, and bronze escutcheon plate identifying system.
2. Single 2-1/2 inch, threads matching local fire district equipment. Use if the riser is less than 3-inches.
3. Interconnect multiple fire department connections so the entire sprinkler system is fed by each fire department connection.

K. Backflow Preventers:
1. General: Provide assemblies complete with manufacturer’s installed OS & Y control valves with indentation for monitoring and strainer on inlet. Pressure loss shall be 5 psig maximum through middle third of flow range.
2. Reduced pressure type: Use for fire suppression systems when chemical additives such as antifreeze are present or when untreated water may be pumped into the system.
3. Double check valve assembly type: Install on each automatic sprinkler and standpipe system at the base of the system riser downstream of the domestic water supply tap.

L. Fire Department Hose Valves for Standpipes:
1. Standpipes are NOT to have hoses and must be Class III, with 2 1/2 inch and 1 1/2 inch reducer (per NFPA 14, Section 3-3.3, exception 2).
2. Thread to conform to local fire department standard.
3. Stairwell standpipe connections are to be made on the intermediate landing, unless a vestibule is designed, in which case, place the connection in the vestibule.
a. Per Aurora Fire Dept. Contact Campus Fire and Life Safety Officer if questions
b. Verify locations with Denver Fire Dept

M. Sprinklers:
1. Nominal 1/2 inch orifice for “ordinary temperature classification except where higher temperature heads are required or shown.
2. Use quick response sprinklers where allowed by NFPA 13 and suitable for the specific project.
5. Non-finished areas: Brass finish, ordinary temperature rating.
7. Localized areas with potential for freezing: Dry pendant or dry pendant sidewall sprinklers.
8. Metal Cabinet and Spare Sprinklers: Refer to Section 01 78 46 – Extra Stock Materials.
9. Guards: Provide on sprinklers subject to damage or located within 7 feet of the floor, or as otherwise indicated for special conditions.
10. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

N. Electrical Equipment:
1. General: Electrical equipment, tamper switches, and devices must be compatible with the fire alarm system.
2. Supervisory Switches: Weatherproof switch housing, and cover with tamper resistant screws, automatic reset capabilities, and capable of being wired in normally open/closed position.
3. Water Flow Detectors: Electronic vane type or pressure activated, with field adjustable built-in retard device, tamper resistant screws. Switch to activate when flow of 10 gallons per minute or more occurs.
4. Low Pressure Supervisory Switches: Provide for dry pipe or supervised pre-action sprinkler systems. 1/2 inch NPT enclosure, field adjustable between 20 psi and 175 psi, weatherproof housing and cover with tamper proof screws.
5. Exterior Alarm Signals: Exterior electric bell with flashing strobe, minimum 6-inch diameter, and audible level of 85 dBA at ten feet. Mount above fire department connection at a height of ten to fifteen feet above grade.

O. Air Compressor:
1. UL listed and sized to replenish the system in 30 minutes. Provide with 20 gallon tank, air filters, safety relief valve, check valve, and pressure switch. Compressor rated for 90 psi. Obtain power from a dedicated circuit wired to the building’s emergency power system.
2. Piping: galvanized or copper.

P. Air Maintenance Device:
1. UL listed and approved for fire protection use.

Q. Fire Pump Bypass Flow Measuring System
1. Victaulic Style 735 Fire Pump Test Meter
2. Or approved.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Pipe inspectors test valve discharge to a wastewater drain. Pipe main drain to a wastewater drain.

B. Coordinate the installation of fire protection materials and equipment above and below ceilings with suspension system, light fixtures, and other building components.
C. Where mounting heights are not detailed or dimensioned, install overhead fire protection services and equipment to provide maximum headroom possible. Install a minimum 1-1/4 inch threaded capped connection on the end of each cross main to facilitate flushing.

D. Do not attach the system riser to the supply connection until the underground piping is flushed, tested, and accepted by the Authority having Jurisdiction.

E. Conceal piping in all areas except mechanical rooms and areas noted on the drawings.

F. Install fire department hose valves no lower than 42 inches above the finished floor and no higher than 60 inches above the finished floor.

G. Install sight glasses on inspector’s test connections where discharge cannot be seen while valves are operated.

H. Terminate inspector’s test connection at a 45 degree elbow with a sprinkler which has the frame and strut assembly removed. Orifice size to be same as the smallest sprinkler installed on the system.

I. Pipe 2-inch main drain to safe location to allow for full flow testing.

J. Install a concrete splash block with a minimum length of 4 feet to direct the drain or test discharge water away from the building.

K. Install tamper switches on all system shutoff valves.

L. Identification:
   1. Valves: identify and label all sprinkler valves. Attach caution signs to all valves controlling water to sprinkler systems in accordance with NFPA 13.
   2. Miscellaneous Fire Lines: Label inspector’s test drain lines, main drain, and fire lines.
   3. Nameplate: Mount hydraulic designed information nameplate at alarm valve and include information in accordance with NFPA 13.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Record inspections and testing on a copy of Material and Test Certificates as shown in NFPA 13.

B. Prior to any test on sprinkler/standpipe systems, flush piping to remove any foreign matter.

C. Hydrostatically test all systems, including fire department connection, to not less than 200 psi for 2 hours. Read test pressure from gauge located at low point of system.

D. Additionally, test dry-pipe and pre-action systems with an air pressure of 40 psi which is allowed to stand 24 hours. Stop all leaks that allow a loss of pressure over 1-1/2 psi over 24 hours.

E. Correct leaks immediately. On threaded pipe, tighten joints. If necessary, dismantle and replace section. Caulking, preening, or stop-leak compounds are not permitted.

F. Test backflow preventer in accordance with state requirements by certified tester.

G. Function Trip Test:
   1. Wet Pipe System: Functionally trip test system components and alarms by opening the inspector’s test connection.
   2. Dry Pipe and Pre-action Systems: Functionally trip test system components and alarms by opening the inspector’s test connection. Maximum dry valve trip test time shall be 15 seconds from the
time the inspector’s test valve is completely open. Maximum water delivery time to the inspector’s test shall be 60 seconds from the time the inspector’s test valve is completely open.

H. Provide backflow preventer state test certification.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide 4 hours of instruction to the University Facilities Operations personnel. Include valve and drain locations, pipe routing, maintenance and testing procedures.

END OF SECTION 21 05 00
SECTION 22 30 00 - PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Installer Qualifications: All plumbing work at the university shall be performed by a State of Colorado licensed contractor under the supervision of a licensed plumber. Contractors shall verify that plumbers are currently licensed by the State of Colorado and shall supply Project Manager with names and license numbers. Contractors shall have a minimum of 3 years of satisfactory performance in conducting the type of work specified.

B. General
1. Provide a service sink with hot and cold water in mechanical rooms. If a water treatment station is located in the mechanical room, locate the sink within 3 feet, and include a combination emergency eye and body washing station.
2. Provide electric water coolers and drinking fountains at ADA heights. Provide duplex units with heights meeting ADA requirements and normal heights in public areas. Consider heights for children in special areas.
3. Fixtures: Provide battery operated, electronically sensing flush valves, with manual override, on core public area water closets and urinals.
4. See section 23 3200 for general information regarding chemical waste.

C. Backflow Prevention:
1. Provide vacuum breakers or backflow protectors on laboratory fixtures and other fixtures that present a hazard for possible contamination.
3. Arrange water piping systems so back siphoning or backflow into domestic systems is not possible. Consider any water discharging through a faucet to which a hose would be attached potentially hazardous by reason of possible backflow from contaminated areas to which the open end of the hose might be exposed.
4. Install backflow prevention on all laboratory faucets and other points where cross contamination may occur in addition to backflow prevention at building supply.
5. Install backflow preventers on all feed lines to irrigation systems and heating and cooling systems.
6. Install a bypass BFP on the main building service for mains 1” and greater. It shall be sized to meet all critical building loads and be no less than 50% of the primary BFP.

D. Hose Bibs and Wall Hydrants:
1. Provide a minimum of 1 domestic water, freeze-proof wall hydrant, per exterior wall, with loose key type handles at outside locations near entrances to a building for wash down and the University Grounds use. Wall hydrants shall have integral backflow preventers. These should be located as inconspicuously as possible consistent with accessibility. Provide separate shut off valve inside.
2. Provide hose bib with integral backflow preventer at all major equipment locations in mechanical rooms, on roofs and close to cooling towers.

E. Kitchen Grease Traps:
1. Avoid interior locations for kitchen grease traps. If required, provide an engineered unit sized to accommodate area served. Locate grease traps outside for easy truck access and servicing, and properly vented.

F. Underground Tanks and Sumps:
1. Underground storage tanks are not permitted without approval of the University Project Manager.
2. Tanks shall be installed by contractors licensed by the State Oil Inspector.
3. Advance permits from State Oil Inspector are required prior to installation, repair, upgrade, removal or abandonment.

4. Notification forms (EPA) shall be sent to State Health Department and State Oil Inspector upon completion of installation of new tanks.

G. Fuel Tanks (Above Ground):

H. Domestic Hot Water Heaters: Where steam is available, provide an instantaneous steam heat exchanger. Gas fired, or small electric heaters are acceptable with approval of University Project Manager. See also section 23 5700.

I. Roof Drain Overflow: Overflow drains shall not drain on to sidewalks or areas where water or ice could present a hazard or nuisance.

J. Janitorial Closets:
   1. Provide Mob Service Basin. Mop Basin to be constructed of monolithic preformed basin material with stainless steel sill.
   2. Mop Basin faucet type to be a/b/e specialty mop sink with pail hook and wall brace.
   3. All plumbing connections to be ½ mnps thread.

K. Water meters: See section 23 0900.

1.2 QUALITY ASSURANCE

   A. Codes and Standards:
      1. Meet the requirements of International Plumbing Code.
      2. Meet the requirements of national laws regarding ADA accessibility, energy and water conservation.
      3. All valves, fixtures and accessories in contact with domestic water shall meet the requirements of NSF/ANSI Standard 61.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

   A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
      1. Lavatories, Sinks, Service Sinks, Mop Service Basin, Water Closets, Urinals:
         a. American Standard U.S. Plumbing Products
         b. Crane Co.
         c. Kohler Co.
         d. Eljer
      2. Stainless Steel Sinks:
         c. Moen; Div. Of Stanadyne
         d. Eljer
      3. Molded Tubs and Shower Units:
         a. Fiat Products
         b. Kohler Co.
         c. Eljer
      4. Faucets:
         a. Chicago Faucet Co. (preferred)
b. American Standard; U.S. Plumbing Products
   c. Zurn
5. Auto Faucets
   a. Sloan Valve Co (preferred)
   b. Zurn
6. Flush Valves:
   a. Sloan Valve Co. (preferred)
   b. Zurn
7. Auto Flush Valves
   a. Sloan Valve Co (preferred)
   b. Zurn
8. Water Closet Seats:
   b. Beneke Corp.
   c. Olsonite Corp
9. Water Coolers:
   a. Elkay
   c. Haws Drinking Faucet Co.
10. Fixture Supports:
    a. JR Smith
    b. Zurn
11. Shower and Tub Trim (Thermostatic):
    a. Bradley
    b. Powers
    c. Speakman
12. Shower and Tub Trim:
    a. American Standard
    b. Kohler
    c. Chicago Faucets
13. Emergency Showers, And Eye/Face Washes:
    a. Guardian Equipment
    b. Haws Drinking Faucet Co.
    c. Bradley
14. Food Waste Disposers:
    a. In-Sink-Erator
    b. Waste King
    c. National
15. Hose Bibs and Faucets:
    a. Zurn
    b. Woodford
    c. Watts Regulator Co.
16. Venturi Flow Measuring Elements:
    a. FDI (preferred)
    b. HCI
    c. Gerand
17. Calibrated Balancing Valves:
    a. FDI (preferred)
    b. HCI
    c. Gerand
18. Automatic Balancing Valves
    a. FDI (preferred)
    b. Griswold
19. Wall and Yard Hydrants:
c. Woodford Mfg. Co.

20. Water Hammer Arresters:
   a. Woodford
   c. Watts Regulator Co.

21. Instantaneous Steam-Water Heaters:
   a. Leslie (preferred)
   b. Spirax Sarco
   c. Grahm

22. Backflow Preventer Equipment:
   a. Watts Regulator Co. (Preferred)
   b. Febco Sales
   c. Wilkins

2.2 MATERIALS, GENERAL

A. Fixtures and Trim:
   1. All vitreous fixtures shall be of a quality commercially known as 'Twice-Fired Vitreous China'.
   2. All enameled ware shall be cast-iron with 'Acid-Resisting Enamel'.
   3. Reference 11 53 00 for Laboratory Fixtures.
   4. Water Closets: Wall mounted or wall-hung type. Floor mounted fixtures permitted on a special need basis. Tank type fixtures are not allowed.
      a. General: White, vitreous china, water saving siphon jet, elongated rim, wall-hung water closet.
      b. Coordinate the flush valve rates with the University Project Manager.
      c. Miscellaneous Requirements or Accessories:
         1) Seat: White plastic, open front seat less cover, with self sustaining check hinge. Seat shall have an antimicrobial compound as an integral part of the plastic and shall match shape of bowl.
         2) Flush valves: Chrome plated valve with vacuum breaker and 1-inch screwdriver stop with vandal resistant protective cap and adjustable tail piece.
         3) Carrier: Commercial carrier with adjustable face plate and fittings.
   5. Urinals:
      a. General: White, vitreous china, siphon jet urinal with integral extended shields, flushing rim.
      b. Coordinate the flush valve rates with the University Project Manager
      c. Miscellaneous Requirements or Accessories:
         1) Carrier: Commercial carrier with top and bottom plates.
         2) Flush valve: Chrome plated valve with vacuum breaker, 1-inch screwdriver angle stop with vandal resistant protective cap and adjustable tailpiece. Limited to 1.0 gallon per flushing cycle.
   6. Lavatories:
      a. General:
         1) Vitreous china, self-rimming counter top 20" x 17" lavatory.
         2) Vitreous china, self-rimming wall hung 20" x 18" lavatory with back splash.
   7. Stainless Steel Sinks: 18 gauge 304 stainless, self-rimming, single or double compartment sink.
   8. Showers:
      a. Fiberglass: Reinforced plastic shower stall with integral molded base and 2 inch drain fitting and chrome plated strainer. Provide with additional reinforcement for grab bars.
      b. Terrazzo: Precast terrazzo shower floor with single threshold and 2 inch integrally cast stainless steel drain with removable stainless steel strainer.
   9. Utility Sink: Acid resistant, enameled cast iron, wall mounted high back sink with wall hangers and stainless steel rim guard; 3 inch cast iron P-trap with enameled interior, painted exterior, floor bracket and chrome plated brass sink strainer with open grid drain.
   10. Mop Service Basin: Precast terrazzo, service basin with 3 inch integrally cast brass or stainless steel drain with removable strainer. Provide stainless steel guards on all sides.
11. Emergency Eye Wash: Wall mounted, vitreous china or stainless steel receptor with mounting bracket, twin chrome plated heads angled to direct water flow into eyes and ocular face area. Provide flag push-type ball valve to stay open until manually closed. Water delivered by Eye Wash shall be tepid (lukewarm). Installation shall meet or exceed the provisions of ANSI Z358.1 (latest version).


13. Combination Emergency Shower and Eye Wash: Floor mounted, free standing, all chrome plated brass construction with 10 inch diameter deluge shower head and eye wash bowl. Shower shall have rigid pull rod to actuate instant-action stay open ball valve. Eye wash shall have twin anti-squirt heads angled to direct water flow into eyes and ocular face area with flag push-type ball valve actuator, valve to stay open until manually closed. Water delivered by the Emergency Shower and Eye Wash shall be tepid (lukewarm). Installation shall meet or exceed the provisions of ANSI Z358.1 (latest version).

B. Water Coolers:
1. Self-contained, wall mounted, stainless steel, mechanically cooled, drinking fountain. Minimum cooling capacity of 8 gallons per hour of 50 degree F drinking water at the inlet water and room ambient temperatures of 80 degree F with adjustable water temperature control. Equip drinking fountains with handicapped fittings. Care shall be taken to specify fountains with basins and spouts to minimize dripping, etc. on floor. Provide with commercial carrier.

C. Trap Primers: Bronze body valve with automatic vacuum break and 1/2-inch connection to domestic water. Operation shall be by time clock initiation of electric solenoid valve.
1. Neoprene sleeve trap guards are not acceptable
2. Pressure differential style primers are not acceptable.

D. Automatic Flow Control Valves (Flow Limiting Devices)
1. The GPM for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within 5% of the specified amount.
2. For 1/2" - 2", the flow cartridge shall be removable from the Y-body housing without the use of special tools to provide access for regulator change-out, inspection and cleaning without breaking the main piping. (Access shall be similar to that provided for removal of a Y-strainer screen).
3. The maximum pump head for the automatic flow control valve shall be limited to 7 feet.
4. Each valve shall have two P/T ports.
5. All automatic flow control devices shall be supplied by a single source and certified flow tests, witnessed by a professional engineer, shall be available.
6. Five year product warranty and free first year cartridge exchange.

E. Manual Calibrated Flow Control Valves
1. Manual balancing devices shall be venturi type as recommended by ASHRAE.
2. Devices shall have a precision formed throat and have a stated catalog accuracy of 3% F.S.
3. The induced differential reading (flow signal) shall be greater than two feet water column at the design flow with the valve in the wide open position.
4. The permanent pressure loss at design flow shall not exceed two feet of water in the wide-open position.
5. The valves are to have differential readout ports fitted with check valve and protective cap, and are to have a memory stop to allow complete shut-off and return to set position without losing the set-point.

F. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.
3.1 INSTALLATION, GENERAL

A. All exposed piping serving plumbing fixtures that may be used for ADA purposes shall have traps and supplies insulated per ADA requirements.

B. Install flushing mechanism for both ADA accessible flush valves and flush tanks to the side of water closet that has the most floor space per ADA requirements.

C. Provide a tempering valve that conforms to ASSE 1070 for all lavatories and sinks used as a public hand wash facility.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Provide copies of State backflow preventer certification tests.

B. Adjusting: After cleaning and flushing operations are accomplished, adjust flush valves, faucets, showers, bubblers for proper flow.

END OF SECTION 22 30 00
SECTION 23 00 00 – PLUMBING, HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

PART 1 - GENERAL

1.1 REFERENCES

A. Manual Part 3, Project Planning and Design Guidelines and Standards

B. Drawing and General Provisions of Contract, including General and Supplementary General Conditions and Division 1 section apply to work in Division 23.


1.2 SYSTEM DESIGN REQUIREMENTS

A. The University Philosophy:

1. The university is extremely conscious of maintenance costs. Give special attention in the design process to provide for sufficient and safe access space for maintenance of mechanical systems. Clearly indicate locations of ceiling and wall access panels and other necessary access space. Provide easy access to rooftop equipment.

2. Exterior mechanical installations must not only be designed for proper functions, but must be considered in the aesthetics of building design. Locate large and unsightly installations hidden from public view and enclose appropriately.

3. Show mechanical installations on drawing elevations of structures including, installations projecting above parapet walls.

4. Design systems to provide flexibility in the future. Provide systems that are easily adaptable to new layouts or changes in use. Layout mechanical rooms with space for future equipment. Study the possibility of future needs, expansion, or new equipment at the time the basic design is being formulated.

5. The university is committed to sustainable, low energy use and environmentally friendly buildings. Apply LEED and High Performance Buildings into design and construction.

B. Certain operations require special HVAC systems consisting of filtration, humidity control, special exhaust systems, or different temperature settings than surrounding spaces. These areas may include, autoclaves, lab equipment, print shop equipment, machine shop equipment, carpentry shop equipment, metal working shops, and laboratories involved in higher level chemical, biological, and radioactive material experimentation. Work with the University Project Manager to identify these areas and determine appropriate design parameters.

C. Notify the University Project Manager of all modifications affecting supply and exhaust air in animal rooms, laboratories, environmental chambers, confined spaces, trailers, office spaces, darkrooms, and buildings or spaces being renovated or modified for special occupancies.

D. Obtain a complete list of the chemicals and gases to be used and stored in laboratories. Use this list to determine fume hood exhaust for flammability, toxicity, corrosiveness, and explosion hazards.

E. If perchloric acid is used, provide a specialized, dedicated hood constructed of stainless steel, porcelain coated, or non-plasticized PVC lined. Label hood “for perchloric acid use only”. Provide the hood with its own non-reactive duct and exhaust fan and built-in water wash-down system.

F. Provide galvanized steel, aluminum, PVC coated, or stainless steel ducts for ventilating bio safety cabinets, chemical fume hoods and flammable storage cabinets. Design and install systems to ensure that hoods and ducts are under negative pressure all the way out of the building.
G. If a hood is tied into an existing central exhaust system serving multiple fume hoods, then the air system will need to be evaluated to determine if it has sufficient capacity for the addition of other exhausted equipment.

H. Provide make-up air to compensate for the air being exhausted. The location and volume of make-up air is critical to assuring proper fume hood operation and worker protection.

I. Air Handling Devices
1. Base calculations on methods and data from the most recent issues of ASHRAE, Fundamentals Handbook.
2. AIHA/ANSI standards shall be utilized for projects with laboratory or industrial ventilation requirements.
3. All AHUs and exhaust fans shall be AMCA certified for sound and air performance.
4. Design air conditioning systems to conserve energy. Systems shall automatically adjust to actual space load conditions to reduce energy consumption at part loads. The use of fan powered terminals and fan coil units are discouraged, and any use of these products must be approved by Building Maintenance and Operations through the University Project Manager.
5. Use the following design temperatures for heating and air conditioning systems:
   a. Winter:
      1) Outside air temperature: -10 degree F. outside air temperature. For 100 percent outside air systems use -20 degree F.
      2) Inside air temperature: 72 degree F.
      3) Wind velocity: 15 mph.
   b. Summer:
      1) Outside air temperature: 100 degree F. dry bulb, 59 Degree F. wet bulb for systems with OSA economizers or 100% OSA Systems, otherwise 95/63.
      2) Inside air temperature: 72 degree F dry bulb, 63 degree F. wet bulb.
      3) Air cooled condensers and dry coolers: 105 degree F.
      4) Wind velocity: 8 mph.
   c. Discuss laboratory, animal holding and other special room requirements with the University Project Manager.
7. Pressurization: All specified pressure differentials are with respect to the adjacent corridor.
   Ante Room (or lab without ante room) Negative 0.01 (In. H2O)
   Laboratory (BSL-2) Negative 0.01 (In. H2O)
   Laboratory (BSL-3) Negative 0.05 (In. H2O)
   Office Positive 0.01 (In. H2O)
   Classroom Positive 0.01 (In. H2O)
   Verify pressurization requirements with the university project manager.
8. Engineer to indicate pressurization relationships, and specify individual CFM offsets for spaces on the drawings.
9. All research and academic laboratories should be designed with negative pressure, inward air flow. Any deviation from that standard would require a completion and approval by EH&S.
10. Locate the supply, return, and/or exhaust in a given space so flow of air will be toward the most contaminated area of that space.
11. Do not provide humidity control except when specifically required by the program plan. When humidity control is necessary use plant steam to generate clean steam through a clean steam generator.
12. Use outside air for cooling whenever economical. Where practical design systems with economizer cycles that automatically allow the quantity of outside air supplied to the building to be modulated.
13. Use transfer fans for cooling for electrical closets where possible except for large main electrical rooms. Do not provide fan coils in secondary electrical closets.
14. Filter loading design pressure drops:
   a. Pre-filters = 0.9 IN WC
b. Final-filters = 1.5 IN WC

c. HEPA filters = 1.5 IN WC

15. Locate air handling equipment inside buildings.

16. Discuss the needs for redundant (2N, where N = the number of devices required to meet the load,) and back up (N+1, where N = the number of devices required to meet the load) systems with the UC Project Manager. On mission critical applications, determine the system’s single point of failure(s).

J. Design systems that require 24 hours/day operation separate from those that may require only 8 hours/day operation. Systems that require 8 hours/day of operation shall be zoned appropriately for unoccupied operation.

1. Equipment cooling with domestic water is prohibited. Cooling loads should be supplied chilled water from the campus district chilled water system. Requests for exemption shall be made to the University Project Manager.

2. Unless otherwise specified, isolate all rotating and reciprocating machines so that 90% of the disturbing frequency shall be eliminated.

3. The university utilizes a central Building Automation System (BAS) for control of HVAC functions. Coordinate HVAC tie-ins with the BAS.

4. Avoid small separate heating and cooling devices such as fan coil units and unit heaters except for energy conservation or to facilitate scheduling of air handlers. Where this equipment is used, it shall be controlled by the BAS.

5. Provide occupied-unoccupied programming of systems to initiate shut down of ventilation, exhaust, fan systems, and pumps wherever possible.

6. Use variable air volume supply and exhaust to compensate for diversities in loads and reduce equipment sizes.

7. Water-cooled or air cooled condensers are acceptable depending upon job requirements. Water-type cooling towers are preferred to conserve energy and should be considered on systems 80 tons and larger.

8. Specify electrical by-pass switch, external to the drive at critical locations, with appropriate safeties on variable speed controllers to allow use of the equipment if the variable speed controller fails.

9. Design systems utilizing campus district steam and chilled water.

10. Hydraulically decouple the building pumped systems from Utility Company and/or campus district systems. Reference Part 3 for Steam and Chilled Water Utility Connection standards.

11. Design hydronic systems with two-way valves.


13. Thermostat Locations: Locate thermostats central to the load and where possible near the door. Mount thermostats 60 inches above finished floor except mount adjustable thermostats in accordance with ADA requirements.

14. For remodel projects, note for demolition of existing piping to the main riser. Demolition of an existing piping system will include removal of components which do not remain as part of the system, all associated abandoned hangers, valves, supports, and all associated equipment.

15. Verify the use of return air plenums with the University Project manager. Where plenums are allowed, all return air grills shall be provided with return air boots.

K. Laboratories - General:

1. Select exhaust fans in a common system to be capable of providing 30 percent extra capacity and pressure. The speed increase shall not exceed the safe recommended speed as specified by the manufacturer of the device.

2. Provide laboratory with 100% exhaust.

3. Where surrounding structures, building air intakes, public gathering places, or other areas may pocket or concentrate chemical exhaust contaminants from the exhaust systems, then the exhaust shall be treated to minimize point source air contamination by using a high plume dilution exhaust fan.
4. Locate laboratory supply air grilles to prevent unwanted cross drafts around specialty equipment such as chemical fume hoods, biosafety cabinets, and atomic absorption spectrophotometers. Airflow shall move from the entrance of the lab towards the lab hood.

5. Maintain lab and entry vestibule under negative pressure.

6. Maintain the lab more negative than the vestibule.

7. Equip hoods with audible and adjustable visual low-flow alarm set to alarm at face velocity as determined by the manufacturer and acceptable with EH&S.

8. Provide redundant/backup HVAC systems for air handlers and exhaust fans serving laboratories.

9. Fume hoods to be VAV.

10. Provide emergency backup power on hazardous exhaust systems and do not shut down upon activation of any alarm. Provide dedicated switches in the building fire alarm panel to allow capability for manual fan shutdown by the fire department.

11. Air change rates in laboratory spaces to turn down based on occupancy. Verify air change rate with the university project manager.

12. For flammable storage cabinets, do not exhaust. If exhaust is deemed necessary, confirm with EHS and AHJ and provide fire damper. Verify exhaust system can accommodate flammable airstream.

13. Provide heat recovery systems on laboratory systems when possible.

14. Coordinate minimum air change rates with the University Project Manager and EH&S.

15. Mount sash sensors outside fume hoods on corrosive chemical applications.

16. The need for a push-button timed over-ride on fume hood sash alarms shall be approved by the University Project Manager and EH&S.

17. Ventilate Chemical Storage Rooms or Waste Storage Rooms.

L. Laboratory HVAC Control: The laboratory control system shall perform the following functions:

1. Hood face velocity

2. Laboratory pressurization

3. Laboratory temperature control

4. Proper air distribution

5. Pressurization (either positive or negative) shall be maintained by airflow based on the formula:
   b. Supply cfm: Air supplied to the space to maintain temperature and provide make-up.
   c. Exhaust cfm: Air leaving the space either through the hood’s exhaust or through the general exhaust.
   d. Offset: Is an arbitrary amount set to provide pressurization.

6. The lab controller (programmable) shall receive inputs from all controlling devices and provide outputs to control the lab’s environment.

M. Standard Laboratories - Biosafety Level 2:

1. Provide 30% reserve capacity in new HVAC systems design to accommodate future research needs and help retard system obsolescence and minimize overall capital outlay.

2. Laboratory air circulation shall comply with ASHRAE standards.

3. Maintain all laboratories under negative pressure.

4. Design laboratory exhaust air grilles with inflow air velocity rates ranging between 500 and 700 linear feet per minute.

N. Standard Laboratories - Biosafety Level 3 (BL3):

1. Design in accordance with the Campus standard “Biosafety Level (BL3) Construction Standards. Copies of this standard are available from the university EH&S.

2. All supply and exhaust from each holding room must be provided with bubble tight control dampers.

O. Photography Darkroom: The Kodak K-13 photo darkroom design standard shall be used as a guide. All photo darkroom designs shall be specified and/or approved by the university DEHS before any implementation. Minimum requirements to control photochemical vapors, fumes, and dusts are as follows:
1. All darkrooms shall have 100% outside air supply. Exhaust shall be discharged away from any building air intake. Provide a minimum of 8 air changes per hour. Maintain all darkrooms at a negative pressure to its surroundings (0.05 in wg.).

2. Desired and compatible temperature ranges for photo darkrooms shall be 69 to 75 degree F.

3. The university DEHS will participate in photo darkroom design, as there may be special requirements associated with numerous processes that generate hazardous gases and shall approve all plans before any construction takes place.

P. Environmental Chambers: These units are variable and shall be evaluated individually by the university DEHS before purchase and/or installation.

Q. Biosafety Cabinets (BSC):

1. Construction of new facilities in campus may require the installation of biosafety cabinets. Some BSCs of the Class II Type B 2 have 100% exhaust requirements. Design of space HVAC systems shall accommodate the exhaust requirements of the BSCs. In addition, filter pressure drops across HEPA filters must be monitored for proper system airflows.

R. Equip multiple hoods on the same fan system with a control damper at each hood

S. Animal Facility Design Conditions:

1. Heat and ventilate animal laboratory and animal facilities by an independent system.

2. Conform to the most current edition of the ILAR "Guide for Care and Use of Laboratory Animals", available from the University Project Manager and/or Institutional Veterinarian.

3. Additional guidelines and design criteria for animal holding areas may be applicable. The University Project Manager shall coordinate with the Institutional Veterinarian for additional guidelines.

4. Provide separate ventilation system for the animal facility and system redundancy and system monitoring. Redundant systems required for supply, exhaust, heating and cooling so minimum environmental conditions can be maintained in animal holding with one unit out of service. Discus requirements with Institutional Veterinarian and the University Project Manager.

5. Size strainers on floor drains to match the size of sewage material from the animal facilities. The University Project Manager shall coordinate with animal facility personnel.

6. All wall and ceiling penetrations (including fire sprinkler heads) to be sealed airtight for vermin control.

7. Provide dedicated exhaust system for the cage wash area due to saturated vapor content. Exhaust duct should be stainless steel.

8. Provide 100% outside air with MERV 15 filtration.

9. All ductwork in animal facilities must be welded stainless steel.

10. All supply and exhaust from each animal hold room must be provided with bubble tight control damper. These dampers are controlled individually thru the BAS for decontamination purposes. Coordinate decontamination requirements with the University Project Manager.

11. Temperature and Humidity criteria: Maintain temp set points +/- 2 deg between 64-84 deg F. Humidity must be maintained between 30-70% with +/- range of 10% RH (with the low not allowed to go below 30% or high above70%). Depending on species, there may be rooms that require temp and humidity levels outside of range. Discus requirements with Institutional Veterinarian and the University Project Manager.

12. All facility systems should be on back-up generator.

13. Locate distribution systems in full accessible interstitial space with a minimum of 6’ 8” clear height. All serviceable components should be accessible.

14. Mechanical systems should be soundproof to minimize disturbance to research animals. Systems should not be located directly above or adjacent to animal holding rooms.

15. Facility should have the following through a central distribution system:
   a. Medical O2 (NFPA 99 certified)
   b. CO2
   c. Vacuum.

16. Animal Watering System:
a. An automatic watering system to all animal housing rooms.
b. Water is RO with acidification.
c. Automatic watering system is flow thru or filtered recirculation system.
d. Stainless steel manifold distribution designed in a way to prevent “dead legs.”
e. System shall be equipped with a programmable flush system for each rack and be centrally monitored for pressure or leaks.
f. System should be designed to include treated storage tanks that are sized accordingly to provide minimum of 48 hours of animal drinking water (when facility is at full capacity) in an emergency.
g. BAS shall monitor system
h. See 23 60 00.

T. Utilities:
1. In general, utilities will be included in Division 2 and work in this Division will only extend to 5 feet outside of Building or Structure excavation perimeter.
2. Specify the following where exceptions occur and Building Services extensions and connections are made to public utilities:
   a. Connection charges, membership fees, system development charges, and the like, that in principle allow the right to obtain a services from a Utility Company will be arranged and paid for by the university.
   b. In the event that the serving Utility Company installs their own taps, service, meters, etc., all costs imposed by this action shall be the responsibility of the Contractor.
3. The Campus is a continuously operating facility. Construction of new and maintenance of existing utility systems, equipment and distribution requires capability of isolation of equipment, systems, and branches of the distribution system. It is therefore imperative that the design and installation of new and modified utility systems include sufficient isolation capability. All work involving the central utility systems (i.e., steam, natural gas, condensate, chilled water, hot water, domestic water, medical gases, and/or vacuum systems), whether upgrade of the system or tie-in to the central system must include provisions for system isolation. Location of isolation devices shall comply with the directives in Section 01040. An isolation plan shall be submitted to the University Project Manager as part of the Schematic Design and Construction Document phases of the project. The University Project Manager will be responsible for approval of the plan and coordination with the Design Team.
4. The University Project Manager will furnish information regarding the preferred locations of incoming utility services to the building and waste outlets. This will generally be furnished in the form of a site plan and pertinent elevations will be given. Piping in the building must be generally arranged and oriented to conform to these. Layouts should not be started until this information has been furnished.
5. All incoming utilities shall be metered. Meter domestic water per Local standards and meter chilled water, electricity and steam per the university standards, which are available through the University Project Manager. Provide for isolation of meter, bypass around meter, and complete shutoff of meter and bypass.
6. All incoming utilities shall be provided with means of isolating the building from the utility distribution system inside the building at the point where the utility enters the building.
7. The University Project Manager will furnish the locations of all underground utilities prior to demolition and excavation.
8. Steam is distributed from the university Central Utility Plant via direct buried lines. Nominal distribution pressure is 125 psig saturated. All building mains shall be dripped and branches backgraded to the main.
9. Install steam service lines to each building with a minimum of 20 pipe diameters straight run for metering.
10. Provide main building shut off valves outside the building typically in the mechanical vault.
11. Insulate all steam and condensate lines. Insulate valves, strainers, and other equipment with removable preformed insulated casings or jackets.
12. Steam condensate is returned to the university Central Utility Plant via direct buried lines.
13. Condensate receivers with mechanical pumps are not permitted without approval by the university Facility Operations through the University Project Manager. If pumps are used, provide centrifugal duplex type with cast iron receiver. Provide float operated mechanical alternator for switching for alternate service. Size receiver capacity for 25% future capacity. Install flash tanks ahead of receivers.

14. Specify methods and locations of trapping.

15. Meter steam supply in each building. Steam and condensate meters must be approved by the university Facility Operations through the University Project Manager.

U. Steam and Condensate Distribution Systems:
1. Campus steam is provided by connecting to the piping headers located inside the designated mechanical utility vault. The utility vaults house the expansion joints and condensate trapping stations for the steam service. All penetrations into the utility vaults shall be constructed such that the watertight seal at the wall is maintained. These header connections are typically 12” Sch 40 steel pipe. Saturated steam at 110-125 psig will be provided for the building at the steam header.

2. Steam Distribution Piping:
   a. An isolation valve must be located in the utility vault downstream of the connection to the steam header. The service pipe from the utility vault to the building shall be according to the standard specification for preinsulated piping systems. The service pipe from the vault to the building shall be anchored in un-excavated soil within 5 feet outside of the vault wall and also outside the building wall in order to minimize the expansion directed into the vault and building. Provision for thermal expansion of the service line must be addressed. Additional expansion loops and anchors may be required depending on the distance and routing. Extreme care should be taken in the design of the high temperature piping systems to avoid excessive stress on the pipe, anchors, vault and building. The slope of the steam connection piping must lie so that the condensate is effectively drained to either the steam header located in the utility vault or to the building.
   b. After the building penetration, isolation flanges and gaskets should be provided to electrically isolate the distribution system from the building in order to prevent electrolytic corrosion on both systems (see REF DWG 1). Provisions to trap the condensate must be made directly after the isolation flanges and gaskets in the building. Downstream of the trapping station an isolation valve must be located inside the building. Directly downstream of the isolation valve and upstream of the condensate header, a vortex-shedding mass flow meter, pressure and temperature compensating, shall be installed (see specification). This meter will be installed in a length of straight pipe dictated by the particular piping configuration and model of steam meter in order to have accurate measurement. The meter shall be sized to accommodate both the maximum and the minimum flow rates anticipated. If the metering accuracy cannot be maintained at both the maximum and minimum flow values of the meter, a parallel dual meter installation will be needed. If necessary, the combination of two meters must be sufficient to measure low load conditions. The meter output shall report to the Building Automation System (BAS) and communicate with the campus network. Meters may need periodic calibration based on the manufacturer’s recommendation.

3. Steam Meter Specification: Please see section 23 09 00

4. Steam Condensate:
   a. Condensate return is done by connecting to the headers located inside the mechanical utility vault. These header connections are typically 4” Sch 80 steel pipe.
   b. An isolation valve must be located in the utility vault upstream of the condensate header and header isolation valve. The service pipe from the utility vault to the building shall be according to the standard specification for preinsulated piping systems. The service pipe must be anchored in un-excavated soil within 5 feet of the vault wall and also outside of the building wall in order to minimize the expansion directed into the vault and building. Thermal expansion of the service line must be provided for outside of the utility vault, between the anchors.

5. Draining Piping Low Points:
a. If it is necessary to trap and drain the connection line in-between the utility vault and the building, and no practical steam main drainage scheme exists, using only pipe slope (either to the building or to the utility vault), then these traps may be connected directly to the pumped condensate return line. Care must be taken in sizing the steam main from the vault to the building because if the building penetration is located higher than the utility vault connection, and it is desired to drain the condensate into the utility vault, over-sizing the steam main to accommodate counter flow conditions may be necessary.

b. Upstream of the building penetration, isolation flanges and gaskets should be provided to electrically isolate the distribution system from the building in order to prevent electrolytic corrosion on both systems. Upstream of the isolation flanges there is located a single trap discharge connection from the steam trap located upstream from the steam isolation valve located inside the building. A steam condensate isolation valve shall be located inside the building upstream of the trap discharge connection.

6. Liquid Mover:
   a. The steam condensate return system is intended to operate in the future under pressure and have no working atmospheric vents after leaving the buildings. All condensate trapped inside the building must be collected in a non-vented receiver and pumped into the condensate return system using a steam motivated steam condensate pump (see REF DWG 1). Please note that the pressure reducing valves serving the steam condensate pumps are fed with the pressure of the main steam line (110-125 psig) upstream of any pressure reducing stations. This allows the motivation pressure of the steam-powered pumps to be adjusted over time to meet the changing system demands without concern regarding the pressure of the steam for use by the building loads.

   b. It is anticipated that the condensate return line back-pressure will increase as more buildings are constructed and come on line. Building condensate return design should be based on the worst case of 35 psig back pressure, yet be adjustable for the low back pressure that will be seen during the first several years.

7. Condensate Return Temperature:
   a. Minimum steam condensate return temperature from the building is assumed to be 180°F. Maximum steam condensate return temperature from the building is assumed to be 200°F. Under no circumstance is live steam (other than flash steam) to be introduced into the steam condensate return lines.

   b. Damage may occur to the insulation and waterproof protective jacketing if excessive pipe surface temperatures are reached. This damage will lower the long-term efficiency and will shorten the service life of the piping system.

V. Chilled Water Distribution Systems
1. The Central Utility Plant (CUP) produces chilled water at 40°F and through a variable flow primary distribution system, provides chilled water to the buildings for cooling. There is an assumed heat pickup during distribution of less than 1°F.

2. As a building design condition, it should be assumed that chilled water will be provided to the buildings at 41°F. Chilled water should be returned to the CUP at 56°F.

3. Chilled Water Connection Configuration:
   a. The campus chilled water distribution system will operate in a de-coupled manner. A primary-secondary bridle connection and building circulation pumps should be used for building cooling. The CUP provision of chilled water uses variable-flow primary pumping to the building infrastructure connection.

   b. Campus buildings use internal secondary loops with variable flow pumping to distribute chilled water to the HVAC (Heating, Ventilation, and Air-Conditioning) and process cooling loads (typically process loads are isolated in a tertiary pumping loop using a heat exchanger).

   c. The primary-secondary pumping interface is an important consideration. Use of a 2-way modulating control valve installed on the return leg back to the CUP is used to maintain a chilled water return of 56°F (see REF DWG 2).

4. Low Delta T Syndrome:
a. The CUP is designed to accept 56°F chilled water return (CHWR) and maintaining this full temperature differential has energy utilization advantages.

b. The energy cost associated with a low delta T can be avoided, but requires that building designers exercise care both in design and commissioning of their respective building projects.

c. An important consideration is the ability of the building to maintain 56°F chilled water return back to the CUP – especially at peak load, but also at part load. As the standard suggests, using a 2-way control valve to hold building return chilled water at 56°F before allowing it to return back to the CUP, can cause building cooling problems. Building designers need to exercise great caution in considering the potential for chilled water mixing in the de-coupling bypass pipe. The commissioning process should be used to verify high CHWR temperatures leaving individual heat transfer devices within the building, in a dynamic setting, at both peak load, and at part load. Relaxing the requirement of CHWR = 56°F will not be a solution to poorly controlled building loads. It is important to consider the matching of flows for building pumping with chilled water demand at the various building loads. Flow meters will be used on both the primary loop and the secondary loop to facilitate Building Automation System (BAS) control logic to approximate flow matching.

5. Special Consideration of CHWR < 56°F:

a. The university accepts, with respect to HVAC loads, that there are certain coil entering air conditions, depending on AHU (air handling unit) design, that will not allow chilled water leaving the coil to reach 56°F.

b. These special circumstances must be identified and approved on an individual building/project basis. Often this is discussed with reference to outside air conditions (OSA), though the range where the OSA temperature impacts specific designs, and consequently the requirement to hold CHWR = 56°F, will differ based on the project. For the most part, this difficult operating range covers a small period of time.

c. This standard is not intended to require a fixed unyielding conformance to the CHWR = 56°F requirement without consideration for undesirable consequences. Unreasonable investment in buildings or wasteful energy practices should be avoided. These exceptions should be discussed, clarified, and approved during schematic design on an individual project basis. During this low coil load scenario, chilled water return to the CUP may be gradually relaxed, at the same time the AHU supply air discharge temperature is gradually raised through a controlled re-set schedule. Using creative instrument control sequences, it may be possible to increase CHWR to greater than 56°F - this is acceptable and desirable (good design practice should strive to minimize all flow through the decoupled bypass/bridal connection – both to artificially cause CHWR = 56°F to be a set maximum or set minimum).

6. 2-way Control Valve:

a. Temperature control of the chilled water return back to the CUP must be maintained through a direct acting temperature control loop. The control valve and actuator assembly must be of industrial quality with a combined approximate 100:1 turn-down ratio.

b. The control valve will need to be able to close against the possible 100 psi (230’ W.C.) differential pressure from the central plant pumps and have 3-5 psid across the valve at full flow.

7. Process Cooling:

a. Process cooling loads may require a special application during periods of low building load (cold outside air temperature conditions). Process cooling loads are assumed to be generally constant irrespective of outside weather conditions, 24 hours per day and 7 days per week (HVAC loads will be able to take advantage of outside air economizers). Process loads should have coils sized for warmer chilled water for those periods of time when the CUP will have elevated supply temperatures as it operates in free cooling mode(it is likely that the heat exchanger could return water warmer than 56°F).

b. Serving process loads during winter weather will often require the use of a smaller “minimum flow” chilled water pump for low load conditions as the main pump VFD
8. CUP Chilled Water Re-set Schedule:
   a. Building design should reflect an increased chilled water supply temperature during cold outside conditions. CUP provided chilled water supply temperature will increase during cold weather as shown in the schedule.
   1) If OSA > 45 F, then building design at CHWS = 41 F (standard condition)
   2) If OSA < 45 F, then building design at CHWS = 46 F (free cooling mode)

9. High Static Head Problem:
   a. CUP pumping operation at future build-out is based on a fixed maximum working pressure. During peak operation, dynamic pump head in combination with potential static head due to a high column of water, could exceed the CUP design basis if precaution is not considered. To that end, the highest point of the building chilled water piping system (including all connected equipment and piping) should not be higher than an elevation of 5,475 FT A.S.L. because of the static pressure induced on the campus system by the building piping system. In this case, use a flat plate heat exchanger(s) and building circulation pump(s) to isolate the building and campus chilled water systems (typically process loads are isolated in a tertiary pumping loop using a heat exchanger, in some cases the entire building will be served by a chilled water heat exchanger).

10. Flat Plate Heat Exchanger:
   a. Use of a flat plate heat exchanger is required when the highest point of the building chilled water piping system exceeds the elevation of 5,475 FT A.S.L. because of high static head. Alternatively buildings may have both a direct de-coupled chilled water connection to the CUP and an indirect connection through the use of a heat exchanger. In many cases, in buildings with significant process cooling requirements, these cooling loads will all be served by a chilled water heat exchanger and a downstream tertiary pumping loop. In either case, the chilled water piping system downstream of the heat exchanger must be considered as an isolated system. This system must have provision to manage its own makeup water and chemical treatment. The piping system downstream of the heat exchanger must have provision for expansion capacity. The tertiary chilled water system should be designed to utilize warmer chilled water to account for both a 3 F approach or less and elevated CUP chilled water supply temperatures during winter operation (please see CUP free cooling mode chilled water supply reset).
   b. If the entire building is served by a flat plate heat exchanger (ideally this should be avoided if AHU’s can be kept below the approximately tenth story roof elevation) – when significant building chilled water equipment is above the specified elevation or if the process cooling heat exchanger is directly connected to CUP chilled water system, then the direct connection of the heat exchanger to the primary chilled water distribution network should be sized for a differential pressure of no more than 6.5 psid at the maximum flow (source side).

11. Central Utility Plant Water Treatment Management:
   a. No makeup water or chemicals shall be introduced into the chilled water system at the building when directly connected to the CUP system. All chemical treatment will occur at the CUP. Piping system expansion capacity for each building project will be provided for at the CUP. The building mechanical systems designer must provide the campus Facilities Operations engineering staff with the calculated amount of expansion required for the building project from the point of connection with the campus system. All equipment and connections shall be specified for 150 psig ratings (flanges, gaskets, Victaulic connections, etc.). This is the rating of the campus distribution system chilled water piping.

12. Chilled Water Meter Specification: Please see section 23 09 00.

13. Reference Drawings:
   a. The following diagrams are referenced in the above text and are for general use and design discussions. Valves are shown as a generic valve symbol and are not meant to depict a particular type of valve. It is important to emphasize again, that each particular installation is unique and may require a different approach to the installation.
   1) REF DWG 1: Steam Connections Inside Buildings
W. Energy Conservation:
   1. The university is dedicated to the principle of conserving energy and will scrutinize proposed
construction for means of reducing not only initial cost, but also long range operating and
maintenance costs. Buildings will be designed making the most efficient use of building materials
and energy sources available. Compliance with the standards in ASHRAE Standard 90 is a
minimum requirement.
   2. Give consideration to building utilization by planning for conservation between summer and
winter and for periods of minimum occupancy. Design systems that require 24 hours/day
operation separate from those that may require only 8 hours/day operation. Systems serving spaces
with special year-round cooling loads e.g., computer rooms, data centers, equipment rooms, shall
be designed separate from the building HVAC system.
   3. Conservation of energy should be a significant factor in specifying or selecting equipment, system,
controls, and sequence of operation. The alternatives shall be evaluated through life-cycle costing
and presented to the campus energy engineer through the University Project Manager for approval.

X. Equipment Rooms:
   1. Separate mechanical equipment rooms from electrical equipment rooms. Limit access to these
rooms to authorized maintenance personnel only. House equipment requiring access by building
or laboratory personnel separately.
   2. Arrange access to equipment rooms so entry will not disturb the occupants or normal functions of
the building. Outside access doors are preferable. Coordinate door sizes with the largest equipment
size. Provide adequate heights for walking and moving equipment into and out of room.
   3. Comply with ASHRAE standards and State of Colorado regulations for design and construction of
mechanical refrigeration systems and related monitoring, ventilation, and storage of refrigerants.
   4. Arrange and locate equipment rooms so that heat and sound will not be transmitted to other parts
of the building. Insulation and ventilation are required where applicable per standard requirements.
Where applicable size service elevators for equipment removal from basements and penthouses.
   5. Locate equipment having parts which must be removed for maintenance (filter, coils, fan shafts,
tube bundles, etc.) so that removal may be accomplished with adequate access and without
interference with other functions of the building.
   6. Surround the room with a 6 inch curb, a 2 inch cant, and waterproof the floor. Provide floor drains
and slope floor to drains.
   7. Provide high water detection alarms in all mechanical and equipment rooms at lowest point of
floor. Provide a 3/4 inch conduit between high water alarm and the specified alarm panel for
remote alarm.
   8. Where possible lifting eyes should be permanently placed to aid in lifting and removal of
mechanical equipment weighing over 100 pounds. Lifting eyes shall not be blocked by any device.

Y. Pipe and Duct Spaces in Chases:
   1. Provide excess horizontal and vertical area in duct chases and pipe runs for future use where
possible 25%, office buildings should have 10% excess.
   2. Provide full size doors for access at each floor of chase with steel floor grating for service and
maintenance. Provide additional reduced size access doors where full size doors will not work to
maintain and service devices and/or components within the duct.

Z. Pipe and Duct Penetrations:
   1. Specify and detail the manner in which pipes pass through roofs, walls, floors, and ceilings. Fire
ratings must be maintained for all penetrations. The Contractor responsible for cutting or drilling
holes and flashing, sealing, or otherwise furnishing them must be clearly designated in the project
documents.
   2. Design pipe, and duct penetrations so that minimum opening remains after installation. Seal
openings to prevent passage of rodents, birds, bugs, fire and smoke. Materials used shall be
sufficient to maintain fire rating of the wall, floor, ceiling and/or roofs.
   3. Provide for continuous insulation for pipes and ducts passing through openings.
4. Provide tubing or pipe (not sheet metal) sleeves for all utility services passing through structural walls and slabs. All sleeves passing through slab floors shall project a minimum of 1 inch above the slab and be sealed water tight to the slab.

5. Provide toe boards and handrails when floor grating is more than 4 feet above the walking surface below.

AA. Provide concrete curbs in mechanical rooms to contain water spills.

BB. Access/Accessibility:
   1. Any device, equipment and/or component having a moving part or that requires maintenance and/or service shall be easily accessible. If it is located above solid ceiling, in a chase or other concealed areas, an access door shall be provided so that parts can be exchanged and work be done as required. Minimum panel size to be 24 inches by 24 inches.
   2. Design and install utility distribution systems (i.e., conduit, piping, ductwork, etc.) in a layered configuration in the areas of renovation or new construction. Take into account the access to devices, equipment, and/or components.
   3. Locate access to equipment and valves outside critical areas, clean rooms, and red zones. Obtain a list of specific areas from the University Project Manager.
   4. Locate systems to provide access to devices and components that require access or maintenance. Design system hierarchy above ceilings as follows:
      a. Plumbing waste, vent piping and roof drain mains and leaders.
      b. Cable trays
      c. Supply, return, and exhaust ductwork
      d. Fire sprinkler mains and leaders.
      e. Electrical conduit and duct banks.
      f. Domestic hot and cold water, medical gas piping
      g. Fire sprinkler branch piping and sprinkler run-outs.
   5. Submit a system layering plan including electrical components to the University Project Manager for review and approval as part of the Schematic design phase of each project.

CC. Acoustical Criteria:
   1. Design systems to provide noise levels from equipment and ductwork not to exceed, ASHRAE NC-35 in class room, 40-45 in laboratories in all 8 octave bands.
   2. Coordinate acoustical requirements for application specific areas.
   3. Exceptions:
      a. Spaces within 15 foot radius from supply and return ducts from shafts: NC-40.
      b. Lobbies, Toilets, Commercial Areas: NC-45 – 50
      c. Kitchens: NC-45 to 50.
      d. Mechanical Rooms: NC-50 to 60.

DD. Temporary Facilities:
   1. Do not use permanent building equipment without written permission from the University Project Manager. If equipment is used for temporary heating or cooling, maintain equipment per manufacturer’s instructions and protect with filters, strainers, controls, reliefs, etc. Do not start the guarantee period until the equipment is turned over to the university for use.

EE. Painting:
   1. All piping, conduit and equipment in unfinished areas shall be painted as required for preservation and identification.
   2. All exposed work in finished areas shall be painted for appearance as directed by the Architect.
   3. Painters will cover or mask off equipment tags, nameplates, etc., before painting and then remove masking in such a way that it does not destroy the information on the tag or nameplate.

FF. Process and Control Air:
   1. Air supply for control of HVAC devices having electric or electronic components shall be dried through a refrigeration air dryer or desiccant dryer.
1.3 SUBMITTALS

A. Submittals shall be made in accordance with Section 01300 and as required by various Section of Divisions 21, 22, and 23 with the following provisions:
   1. Submittals will be reviewed by the Engineer to determine that the materials, equipment, and installation methods are in accordance with the project design concepts. The Contractor shall be responsible for space requirements, configurations, performance, bases, supports, structural members and openings in structure, and other apparatus that may be affected by the material, equipment, or installation.
   2. Include current, published catalog and specification sheets pertaining to proposed material and equipment.
   3. Identify each item with identification symbols identical to those used on the drawings and/or in the specifications.

B. Operation and Maintenance Manual: Furnish operation and maintenance manuals for equipment and systems installed under Divisions 21, 22, and 23 of the standards in accordance with Section 01730 and the following.
   1. Submit one copy of the manual to the Engineer for preliminary review prior to production of the final manuals.
   2. Following review of the preliminary manual by the Engineer prepare and submit final copies of the manual complying with the Engineer's comments noted on the preliminary manual.
   3. Include the following information:
      a. Alphabetical list of all system components with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
      b. Manufacturer's data that are applicable to the installed equipment such as the following:
         1) Shop drawings (reviewed and accepted)
         2) Product and performance data (reviewed and accepted)
         3) Installation instructions
         4) Lubrication instructions
         5) Wiring and temperature control diagrams (reviewed and accepted Shop Drawings)
         6) Parts lists
         7) Copies of warranties
         8) A compilation of the manufacture’s recommended maintenance schedule and routines for each piece of equipment
      c. A simplified description of the operation of each system including, the function of each piece of equipment within the system. Support descriptions with a schematic flow diagram when applicable.
      d. Emergency procedures for equipment operation during a fire or following the failure of major equipment. Describe procedures for normal starting, operating, shutdown, and long-term shutdown.
      e. Maintenance instruction including valves, valve tag, and other identified equipment lists, proper lubricants and lubricating instruction for each piece of equipment, and necessary cleaning, replacing, and adjusting schedules.
      f. Assembly, installation, alignment and adjustment instructions.
      g. System balancing report.
      h. Temperature controls, cut sheets and record drawings.
      i. Commissioning checklists and certification.

C. Record Documents: Furnish record documents for equipment and systems under Divisions 21, 22, and 23 of the Standards in accordance with Section 01720 and the following:
   1. Mark drawing prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers, and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control
devices located and numbered, concealed unions located. Note changes of ductwork or piping on the drawings if it has been relocated more than 1 foot from where shown on the drawings.

2. List all equipment parameters on the drawings in schedules whenever possible. Include room number where equipment is located.

3. At the completion of the project, mark all valve tag numbers on the drawings and turn these drawings over to the University Project Manager.


D. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

1.4 QUALITY ASSURANCE

A. Installer Qualification:
   1. Workmanship shall conform to the highest industry standard for each specific type of work.
   2. Perform work in accordance with standard commercial practices.

B. Comply with Part 3 of this manual, state and federal codes, rules and regulations. As a minimum requirement, codes, rules and regulations take precedence over the drawings and specifications. Where the requirements of the drawings and specifications exceed those of applicable codes, rules and regulations, the drawings and specifications shall govern.

C. Chemical and physical properties, design, and performance characteristics of all material and equipment, and methods of construction shall be in accordance with the following applicable codes, regulations and standards. Current editions in effect 30 days prior to receipt of bids will apply.
   1. Air Conditioning and Refrigeration Institute (ARI)
   2. American Gas Association (AGA)
   3. American National Standards Institute (ANSI)
   4. Air Movement and Control Association, Inc. (AMCA)
   5. (ASHRAE) American Society of Heating, Refrigerating and Air Conditioning Engineers
   6. American Society of Mechanical Engineers (ASME)
   7. American Standard Code for Pressure Piping (ASCPP)
   9. American Society of Mechanical Engineers (ASME)
   10. American Standard Code for Pressure Piping (ASCPP)
   11. Compressed Gas Association (CGA)
   12. Environmental Protection Agency (EPA)

1.5 DELIVERY, STORAGE AND HANDLING

A. All mechanical equipment and materials shall be delivered, stored and handled in accordance with manufacturers instructions and the requirements of Section01 10 00.

1.6 WARRANTY

A. All mechanical equipment, materials and workmanship warranties shall be provided in accordance with the requirements of Section 01740 and the following:
   1. Warranty all equipment, materials, workmanship, and proper operation of equipment and apparatus for a period of one year from date of final acceptance unless indicated otherwise in the individual sections. Extended warranty periods are identified in individual sections.
   2. Compile and assemble the warranties specified in the individual sections into the operating and maintenance manuals.
   3. Provide complete warranty information for each item to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

PART 2 - PRODUCTS
2.1 MANUFACTURERS

A. As specified in individual sections.

2.2 MATERIALS, GENERAL

A. Products:
1. Provide material and equipment new and free from defects.
2. Install all material and equipment in accordance with the manufacturer's current published recommendations.
3. Certain materials and equipment are specified by manufacturer and model or catalog number. Such specified items are the basis of design and establish a degree of quality, performance, and physical configuration.
4. Equipment and materials manufactured by any one of the manufacturers listed on the drawings or in the specifications will be acceptable.
5. Where no manufacturer is listed, provide a standard product meeting the requirements of the drawings and specifications, and manufactured by a firm regularly engaged in the manufacture of such products. All equipment, when possible, shall be:
   a. Manufactured and purchased in Colorado
   b. Manufactured and purchased in the USA.
6. Requests prior to bid for approval of equipment or material not specified shall be done in accordance with the requirements of Section 01 25 00.

PART 3 - EXECUTION

A. Additional charges will not be authorized due to the contractor's failure to become familiar with the existing conditions.

3.2 INSTALLATION, GENERAL

A. Permits and Inspections:
1. Secure all required permits, the university will pay for permit and inspection costs.
2. Pay all applicable royalties, inspection fees, taxes, and licenses.

B. Responsibility of Contractor:
1. The contractor is responsible for the complete installation and satisfactory operation of all work in accordance with requirements of the drawings and specifications.
2. The component parts of the installation shall function together as workable systems. Each system shall be left with all parts adjusted and in proper working order.

C. Coordination:
1. Coordinate project in accordance with Section 01040.

D. Scaffolding, Rigging, and Hoisting:
1. Provide all scaffolding, rigging, and hoisting necessary to safely accomplish the work following OSHA requirements.
   a. Remove from premises when no longer needed.
2. Provide necessary services to deliver, erect, place, and install all equipment and apparatus furnished.

E. Damaged Surfaces:
1. At completion of the work, all mechanical material and equipment furnished shall be inspected for damage.
   a. Repair damaged factory finishes to match adjacent, undamaged areas.
b. Replace deformed metal cabinets, jackets, and enclosures with new items. Finish shall match similar undamaged items.

3.3 TESTING, CLEANING AND CERTIFICATION

A. Cleanup:
   1. At completion of the work, check and thoroughly clean all equipment.
      a. Clean coils and plenums.
      b. Clean under, in, and around equipment.
         1) Clean exposed surfaces of piping, ducts, and hangers.
         2) Clean equipment cabinets and enclosures.
         3) Provide and install new filters for equipment.

B. Project Closeout:
   1. Verify that all work has been completed prior to requesting final walkthrough, including Contractor’s preliminary review of mechanical systems start-up and acceptance checklists.

3.4 COMMISSIONING (DEMONSTRATION)

A. Training and Demonstration: Schedule instructional meetings for the university’s Facilities Operations maintenance personnel on the proper operation and maintenance of mechanical systems. Provide the project manager a minimum of 5 days notice prior to any training, demonstration, or testing.

PART 4 - ILLUSTRATIONS
A. REF DWG 1: Steam Connections Inside Building
B. REF DWG 2: Chilled Water Connections Inside Building

END OF SECTION 23 00 00
SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Provide mechanical/electrical coordination schedule on the drawings and coordination section in the specifications to clarify power and control wiring.

B. Altitude Deration: Motors shall operate within nameplate horsepower at 5000 feet elevation. Do not operate on service factor.

C. Energy Efficiency: Select and specify energy efficient motors with nominal efficiency equal to or greater than that stated in NEMA MG 1, 1.41.3, for motor type and rating. Motors specifically manufactured for a particular piece of equipment with a lower efficiency shall be brought to the attention of the Project Manager.

D. On variable frequency drives (VFD) applications Provide motors rated for inverter-duty with attached steel nameplate indicating “Inverter-Duty Motor”

E. Use VFDs to drive motors 1- horsepower or larger on variable flow systems

F. Starters: Starters shall be specified in Division 26. Consult with Electrical Engineer and ensure starters are scheduled and provided.

G. Motor drive sheaves shall be a minimum of one size smaller than the driven pulleys. No variable pitched sheaves allowed.

H. Motor Control Centers:
   1. Where a large group of starters can be centrally located, it will be beneficial to have these assembled in a motor control center (MCC) and specified in Division 26.
   2. Where starters are specified in a MCC in Division 26, close coordination is required with the Electrical Engineer to make sure starters match specific motor requirements for part winding start, auto transformer type starting, wye/star-delta closed transition type or where two speed motors have been specified.
   3. Provide adequate space in design for installation of field panels to contain relays and point cards for remote start-stop and status indication.

I. Manual Control:
   1. Specify maintained-contact push buttons with pilot lights for single-speed or multi-speed operation.

J. Automatic Control:
   1. Specify magnetic starters for motors 1/2 horsepower and larger and for smaller motors with interlock or automatic operation.
   2. Specify auxiliary contacts if needed. Provide space for future.
   4. Specify trip-free thermal overload relays for each phase. Size for 125 percent of rated load.

1.2 WARRANTY

A. Provide option for an extended warranty package on variable frequency drive package including motor matched to drive.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Motors
      a. Baldor
      b. Magneteck
      c. Toshiba
   2. Variable Frequency Drives: Purchase VFD and motor from one distributor. Drive manufacturers shall submit a list of acceptable motors for use with the proposed drive.
      a. Toshiba
      b. Siemens
      c. ABB

2.2 MATERIALS, GENERAL

A. Motor Frames and Mounts: Equip motor frames with two axis adjustments, namely slotted frame ends for adjusting in shaft direction and two adjusting screws for belt tensioning.
   1. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
   2. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.
   3. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
   5. Provide inverter-duty motors specifically designed for variable speed operation with premium efficiency at part load conditions a constructed with Class F insulation for equipment specified to operate with variable frequency drives.
   6. Phases and Current characteristics: Unless indicated otherwise, provide squirrel-cage induction poly-phase motors for 3/4 hp and larger, and provide capacitor-start single-phase motors for 1/2 hp and smaller, except 1/6 hp and smaller may be split-phase type.
   7. Provide motors for operation at 5000 foot elevation or higher.
   8. Motors smaller than 1 hp to be single-phase. Motors larger than 1 hp to be 3-phase.
   9. Motors 1 HP and larger shall be inverter-duty, with nominal efficiency equal to or greater than that stated in NEMA Standard MG1, 1.41.3.
   10. Match motor electrically to the drive (a package unit).
   11. Motors for pulse-width modulating (PWM) drives will have both motor bearings isolated.
   12. Motors, 5hp and larger, must be driven by PWM.
   13. Bearings:
      a. Ball or roller bearings with inner and outer seals on sizes up to 1.5”. Ball or roller bearings with inner and outer shields on sizes greater than 1.5” shaft dia.
      b. Regreasable except permanently sealed where motor is normally inaccessible for regular maintenance.
      c. Sleeve type for light-duty, fractional horsepower equipment.

B. Drives:
   1. Rated capacity of V-Belt drives shall not be less than 150 percent of motor nameplate horsepower.
   2. Fixed pitch sheaves, including single groove fan sheaves shall be of the bushed type. No fixed pitch sheave shall be smaller than 3” dia.
   3. Variable pitch sheaves are not allowed.
   4. Provide OSHA approved belt guard with tachometer holes.
   5. For equipment serving hazardous or critical systems such as fume hoods, and bio-hazards, provide fans with a minimum of two-groove sheaves and fan belts.

C. Variable Frequency Drives:
1. Drive shall convert constant frequency AC line voltage to a variable frequency, variable voltage AC output suitable for control of variable frequency, NEMA design B induction motor, with full-load amp rating between 10 percent and 110 percent of the drive full load current capability, without requiring modifications to the motor or drive.

2. VFD for motors shall have the following features:
   a. One motor per drive. No sharing of drive by two motors, except for air handler “fan–wall” applications. Provide separate overload for each fan in “fan wall”.
   b. Pulse width modulation.
   c. Enclosure type - NEMA 1. Provide bypass power and controls in separate enclosure.
   d. AC line fused disconnect or circuit breaker. Provide door interlock disconnect.
   e. AC line reactors in drive cabinet for protection against line notching and surges without requirement for an input isolation transformer. Minimum impedance of line reactors shall be 2.5 percent. Maximum total harmonic distortion shall not exceed 3 percent per IEEE. Input isolation transformers are not permitted.
   f. Metal oxide varistors on incoming line for transient protection.
   g. Manual speed potentiometer, HAND-OFF-AUTO switch and 4-20 milli-amp signal follower, fully isolated and suitable for grounded or ungrounded input signal.
   h. RS485 communication port and protocol capable of full communication with the Siemens FLN. The drive control should act as an application and allow monitoring and manipulation of points from the Siemens front-end software. VFD parameters to be password protected. VFDs shall stop when there is no longer communication to the BAS system, unless otherwise required.
   i. Current Rating: A minimum continuous current rating of the VFD shall be a continuous ampere rating suitable for operation of a premium efficiency motor, VFD continuous amps shall not be less than the amps specified in NEC Table 430-150 for the specified horsepower motor. Additionally, provide VFD to operate at 125 percent of design motor load. Overcurrent rating shall be 110 percent for one minute minimum.
   j. Instantaneous overcurrent shutdown with indicator lamp when current exceeds 200% of nameplate values.
   k. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
   l. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
   m. Input phase loss and under voltage protection.
   n. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
   o. Automatic restart circuitry to restart motor after a momentary or sustained power failure, phase loss, or non-damaging fault trip. No more than 5 restart attempts should be allowed before lockout. Auto restart feature shall be switch defeatable. For fan applications, the VFD shall be capable of restarting into a spinning load.
   p. Cabinet ground lug in VFD enclosure.
   q. Troubleshooting diagnostic features of diagnostic fault display to show reason for trip. Display shall differentiate between: input under voltage, input phase loss or blown fuse, instantaneous overcurrent, sustained motor overload, heat sink over-temperature, over voltage, etc. Diagnostic test unit may be of the plug-in type, with one test unit provided for several VFDs. If plug-in type unit is provided, provide minimum of one for each building.
   r. LED indicators, for all normal operation functions, including on-off status of all power SCRs or transistors, and bypass LED indication when the drive is in bypass.
   s. Test mode switch to allow operation and setup of control electronics with power circuitry disabled.
   t. Availability of critical speed avoidance option which could be added to VFD in the field at a future date.
   u. UL listed.
   v. Rated and sized for 5000 foot elevation operating condition.
w. Automatic soft start feature to start motor at lowest speed and ramp slowly up to required speed on start-up and for any abrupt increases in required speed.
x. Factory test of each unit for a minimum of 2 hours of burning at elevated temperatures of 122-176 degree F prior to shipping.
y. Bypass device (automatic and manual) to allow for total isolation of drive unit for service, while providing for temporary operation of motor. This shall include:
   1) A main disconnect switch in the bypass enclosure with a door interlock handle which provides positive shutdown of all power to both bypass circuitry and VFD. The by-pass shall be in a separate enclosure from the VFD.
   2) VFD output contactor and a constant speed contactor.
   3) Three pole motor overload relay with heaters connected to shut down the motor in both VFD and bypass modes.
   4) Timing relay adjustable 5-30 seconds to prevent rapid switching from bypass to VFD modes.
   5) A control relay and terminal blocks which allows two-wire, start-stop control of motor from a single remote contact in both VFD and bypass (auto) modes.
   6) Control relay and terminal blocks to allow connection of remote interlock shutdown contacts such as freeze stats, smoke detectors, etc. When this interlock loop is opened, operation of the motor shall be disabled in both VFD and bypass modes.
   7) Four position oil-tight selector switch for VFD-OFF-BYPASS (AUTO)-BYPASS (MANUAL). Indicator lights on face of bypass panel with long life neon or transformer type incandescent bulbs to indicate "POWER ON", "MOTOR ON VFD", "MOTOR ON BYPASS CONTROL", "MOTOR OVERLOAD", "INTERLOCK SHUTDOWN".
   8) 120 volt control power transformer with fused secondary and primary.
   9) Bypass mode operation shall be independent of VFD control power.
  10) Output contactor shall be wired to allow a controlled VFD deceleration ramp to stop.
  11) Panel shall be arranged to allow power-off maintenance of VFD while motor is operating on bypass. Bypass circuitry in same compartment as VFD is not permitted.

z. Locate test switches, LED readouts or digital readouts on outside of panel.
aa. Correction for long-lead length as pertains to over voltage problems at the motor will be the responsibility of the installer. Electrical correction will be implemented as required to achieve and maintain safe and smooth motor operation. Leads shall not be longer than 50 ft.
bb. Provide current transformers with adjustable, internal, current sensitive, normally open and normally closed contacts (one each), for Bypass, Drive, and motor contactor conductors (for status).
cc. At least two pre-set speed-control modes in drive circuitry.
 dd. Disconnect at motor shall have auxiliary contact so that when disconnect is opened, the control circuitry to the drive will be interrupted.
 ee. VFDs shall not be located inside the cabinets of controlled equipment.
 ff. VFD shall control interlock with associated damper end switches. Coordinate with sequence of operations.
 gg. VFDs to be programmed for speed not less than 18Hz or 30%.

3. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.
4. Provide shaft grounding kits for all motors used with VFDs. SGS systems preferred.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Motor Frames and Mounts: Mounts for adjustments of belt tension shall be of the two-pull variety.
B. Variable Frequency Drives: Install floor mounted variable frequency drives on 4-inch high concrete housekeeping pad.

C. Correction for long-lead length at the motor will be the responsibility of the installer. Electrical correction will be implemented as required to achieve and maintain safe and smooth motor operation.

D. Disconnect at the motor shall have auxiliary contact so that when disconnect is opened the control circuitry to the drive will be interrupted. Provided by Division 26.

E. VFD shall have sheet metal splash pans above the drives when hydronic piping is located above the VFD.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Factory test variable frequency drives under simulated operation. Provide certification of factory test.

B. Testing: Test and start VFD’s and bypass under actual conditions by factory trained personnel. Operate VFD’s through its full range to determine resonant speeds.

3.3 COMMISSIONING (DEMONSTRATION)

A. Start-up of variable frequency drive equipment shall be performed by factory authorized representative. Provide checklist certifying equipment startup and operation.

3.4 TRAINING

A. Provide the university’s representative 2 hours of training by factory authorized representative for each variable frequency drive installed. Training includes startup, shutdown, emergency operation, maintenance and servicing.

END OF SECTION 23 05 13
SECTION 23 05 19 - METERS AND GAUGES

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Air Filters: Provide pressure switches and manegelic gauges across main building air filters. Monitor each section separately and monitoring and gauges shall have separate tubing.

B. Pressure Reducing Valves: Provide single pressure gauge on upstream and downstream of pressure reducing valves to independently indicate high and low pressure.

C. Heating Water Systems: Provide solar-powered digital thermometers in wells on hot water systems, domestic and heating, to indicate supply and return temperatures.

D. Air Systems: Provide visual on HVAC air distribution equipment to indicate temperatures at supply, return and mixed air points.

E. Pumps: Provide separate pressure gauge in suction and discharge and temperature taps in pipes at each pump section and discharge. Do not use pump housing ports for gauges.

F. Chilled and Condenser Water Systems: Provide dial thermometers in wells to indicate supply and return temperatures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Glass Thermometers:
   a. Marshalltown Instruments, Inc.
   b. U.S. Gage
   c. Mueller

2. Direct Mount Dial Thermometers:
   a. Marsh Instrument Co.; Unit of General Signal
   b. Trerice (H.O.) Co.
   c. Weiss Instruments, Inc.

3. Remote Reading Dial Thermometers:
   a. Ametek/U.S. Gauge
   b. Marsh Instrument Co.; Unit of General Signal
   c. Weiss Instruments, Inc.

4. Dual Type Insertion Thermometers and Wells:
   a. Marsh Instrument Co.; Unit of General Signal
   b. Taylor Instrument Co.
   c. Weiss Instruments, Inc.

5. Temperature Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Universal Lancaster

6. Pressure Gauges and Plugs:
   a. Ametek/U.S. Gauge
   b. Marsh Instrument Co.; Unit of General Signal
   c. Weiss Instruments, Inc.

7. Pressure Gauge Connector Plugs:
2.2 MATERIALS, GENERAL

A. Thermometers:
   1. Case: Die cast aluminum, finished in baked epoxy enamel, glass front, spring secured, 9 inches long.
   2. Adjustable Joint: Die cast aluminum, finished to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.
   3. Tube and Capillary: Spirit filled, magnifying lens, 1% scale range accuracy, shock mounted.
   4. Scale: Satin faced, non-reflective aluminum, permanently etched markings.
   5. Stem: Copper plated steel, or brass, for separable socket, length to suit installation.
   6. Range: Conform to the following:
      a. Hot Water: 30 degree - 240 degree F with 2 degree F scale divisions.
      b. Chilled Water: 0 degree - 100 degree F with 2 degree F scale divisions.

B. Dial Type Insertion Thermometers
   1. Type: Bi-metal, stainless steel case and stem, 1 inch diameter dial, dust and leak proof, 1/8 inch diameter stem with nominal length of 5 inches.
   2. Accuracy: 0.5% of dial range.
   3. Range: Conform to the following:
      a. Hot Water: 0 degree - 240 degree F
      b. Chilled Water: 0 degree - 100 degree F

C. Thermometer Wells:
   1. Thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2 inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

D. Temperature Gauge Connector Plugs:
   1. Temperature gauge connector plugs pressure rated for 500 psi and 200 degree F (93 degree C). Construct of brass and finish in nickel-plate, equip with 1/2 inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch OD probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

E. Pressure Gauges:
   1. Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.
   2. Case: Drawn steel or brass, glass lens, 4-1/2 inch diameter.
   3. Connector: Brass with 1/4 inch male NPT. Provide protective siphon when used for steam service.
   4. Scale: White coated aluminum, with permanently etched markings.
   5. Range: Conform to the following:
a. Vacuum: 30 inch Hg - 15 psi  
b. Water: 0 - 200 psi  
c. Steam: 0 - 150 psi. High pressure  
  1) 0 - 25 psi. Low pressure

6. Provide all steam pressure gauges with pigtail and shut-off valve suitable for temperature and pressure for specified service.

F. Pressure Gauge Cocks:  
1. Brass with 1/4 inch female NPT on each end and “T” handle brass plug  
2. Siphon: 1/4 inch straight coil constructed of brass tubing with 1/4 inch male NPT on each end. On steam pipe only.  
3. Snubber: 1/4 inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

G. Pressure Gauge Connector Plugs:  
1. Provide pressure gauge connector plugs pressure rated for 500 psi and 200 degree F. Construct of brass and finish in nickel-plate equipped with 1/2 inch NPS fitting, and self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch OD probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

H. 2-1/2 Inch and Larger Venturi Flow Measuring Elements:  
1. Primary flow measuring elements consisting of solid brass or bronze venturi tubes. Tubes larger than 2 inches may be cast iron or steel. Steel tubes may be fabricated or cast with cadmium or zinc-plating. Line throats of cast iron tubes with bronze and plate cast iron portion with cadmium. Each station complete with safety shutoff valves, and quick coupling connections for use with a master portable meter set or individual permanently mounted meter. Tubes calibrated and tested by independent testing laboratory and performance data furnished with shop drawings.  
2. Manufacturer shall certify venturi for actual piping configuration. Any necessary piping changes required for certification shall be provided without cost.  
3. Provide venturi with throat diameter such that specified rate of flow will register scale reading of between 20% and 80% of full scale value.  
4. Unrecovered head loss at maximum flow shall not exceed 10% for venturi used with permanently located meters and shall not exceed 12 inches w.g. when used with portable meters.  
5. Provide each primary element with integral tab or metal tag on stainless steel wire extending outside pipe covering on which is stamped or clearly printed in plainly visible position the following information:  
   a. Manufacturer’s name and address.  
   b. Serial number of meter to which element is to be connected.  
   c. Name, number or location of equipment served.  
   d. Specified rate of flow.  
   e. Multiplier (including unity, where applicable) to be applied to meter reading, including correction for operating temperatures and glycol solutions.  
6. Provide taps with shutoff valves and quick connecting hose fittings for portable meters.

I. Inches and Smaller Calibrated Balance Valves:  
1. Calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT O-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.

J. Portable Flow Meters:
1. Provide differential pressure gage and two 12-foot hoses in carrying case with equalizing manifold, check seals, and appurtenances. Plus or minus 2 percent accuracy between 20 to 80 percent of range. Provide master chart for conversion of meter readings to gallons per minute. Provide adapters as necessary.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Temperature Gauges:
   1. General: Install temperature gauges in vertical upright position, and tilted so as to be easily read by observer standing on floor.
   2. Locations: Provide in the following locations and elsewhere as indicated:
      a. At inlet and outlet of each chiller.
      b. At inlet and outlet of each condenser.
      c. At inlet and outlet of each hydronic coil in air handling units and built-up central systems.
      d. At inlet and outlet of each hydronic heat exchanger or converter.
      e. At inlet and outlet of each hydronic heat recovery unit.
      f. At inlet and outlet of each thermal storage tank.
      g. At inlet and outlet of each pump.
      h. At each air handler to monitor Supply Air, Return Air, and Mixed Air temperatures.
      i. Primary and secondary chilled water supply and return and bridal connection
   3. Thermometer Wells: In vertical upright position. Fill well with oil or graphite, secure cap.
   4. Temperature Gauge Connector Plugs: Located on pipe at most readable position. Secure cap.

B. Pressure Gauges:
   1. General: Provide pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
   2. Locations: Provide in the following locations:
      a. At suction and discharge of each pump.
      b. At inlet and discharge of each pressure reducing valve.
      c. At water service outlet.
      d. At inlet and outlet of water cooled condensers and refrigerant cooled chillers.
      e. At steam source heating equipment including but not limited to converters and hot water generators.
      f. At BAS heating or cooling differential pressure sensor
   3. Pressure Gauge Cocks: Provide in piping tee with snubber. Install siphons for steam pressure gauges.
   4. Pressure Gauge Connector Plugs: Located on pipe at most readable position. Secure cap.

C. Flow Measuring Devices:
   1. General: Provide flow measuring devices on piping systems located in accessible locations at most readable position.
   2. Arrange piping in accordance with manufacturer’s published literature. In horizontal pipes, place connections slightly above horizontal centerline of pipe.
   3. Install so connections for attachment to portable flow meter hoses is readily accessible
   4. Locations: Provide in the following locations and elsewhere as indicated:
      a. At discharge of each pump.
      b. At inlet of each hydronic coil in built-up central systems.
   5. Calibrated Balance Valves: Provide on piping with readout valves in vertical upright position. Maintain minimum length of straight unrestricted piping equivalent to 5 pipe diameters upstream and downstream of valve and/or fittings.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
B. Cleaning: Clean windows to meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer’s touch-up paint.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

END OF SECTION 23 05 19
SECTION 23 05 23 - GENERAL-DUTY VALVES FOR PIPING

PART 1 – GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. General Information:
   1. Show all valves on the drawings. Do not rely on a general note in the specifications or on the plans.
   2. For applications up to 2”, specify full port ball valves. Butterfly valves are acceptable if pressure and leak risks are low.
   3. Valves adjacent to equipment should have unions/flanges provided to allow for removal with minimal labor effort.

B. Isolation Valves:
   1. Provide valves for isolating sections of piping systems. It should be possible to isolate; the entire building, separate floors, separate wings, toilet rooms, machinery rooms and other natural subdivisions of the buildings.
   2. Provide valves for isolating equipment and fixtures. Place valves on both sides of backflow and check valves to permit inspection.
   3. Do not use isolation valves for balancing and do not use balancing valves for isolation.
   4. Isolation valves can be ball type (up to 2 inch), gate, or butterfly as deemed appropriate by designer for the type of service, pressure, and fluid.
   5. Ball valves are acceptable as isolation valves for most hot water heating systems, domestic water systems, distilled or ionized water systems, blow-down valves, drain valves and other low hazard, low pressure systems.
   6. Gate valves are required as isolation valves for steam supply and condensate return systems, chilled water supply, and condenser water systems and other high hazard, high pressure systems. Gate Valves installed on steam systems must have stainless steel gates and seats
   7. Butterfly valves are acceptable alternates as isolation valves for chilled water systems, and other low hazard, low pressure, systems where the entire system can be shut down if necessary to accommodate leaky isolation valves.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Hydronic Ball Valves: Apollo, Crane, Jamesbury or Jenkins.
B. Hydronic Gate Valves (less than 2 inches): Stockham, Crane, Grinnell Corp, or Jenkins.
C. Hydronic Gate Valves (2 inches or larger): Crane, Jenkins, Lunkenheimer, or Walworth.
D. Hydronic Butterfly Valves: Dezurik, Crane, Jenkins, Stockham, Keystone or Centerline.
E. Steam and Condensate Gate and Globe Valves: Stockham, Crane, Jenkins, or Walworth.
F. Steam and Condensate Butterfly Valves: Jamesbury, Vanessa, or Keystone.
G. Heating Water P/T Relief Valves: Bell & Gossett, Watts, Farris, Kunkle, Watts Regulator Co., or Spirax Sarco.
H. Circuit Setters: FDI, Armstrong, Bell & Gossett, Tour Anderson.
2.2 MATERIALS, GENERAL

A. Ball Valves:
   1. Blowout proof stems, 3-piece, full port type, brass or bronze body, chrome plated or stainless steel ball, Teflon seals and seat, vinyl-covered handle with memory stop. Pressure rating 150 psi SWP and 600 psi WOG.
   2. Ball valves shall be 2 inch or less. Larger pipe sizes shall require gate or butterfly valves.

B. Gate Valves: Solid wedge, rising stem type, except where clearance is a problem.

C. Globe Valves: Renewable disc, rising stem. Install where throttling may be necessary.

D. Butterfly Valves: Cast iron body, lug style, 150 psi pressure rating, aluminum bronze disc, 416 stainless steel stem, EPDM seat. Provide with cap screws instead of stud bolts to permit valve to remain in place with one flange removed.

E. Balancing or Throttling Valves:
   1. Use eccentric plug, globe or angle valves for balancing. Do not use gate valves.
   2. Butterfly valves equipped with memory stops may be used as balancing valves.

F. Safety Relief Valves: Brass or bronze body, designed, rated, and stamped in accordance with ASME. Steel and cast iron body valves may be used for steam service.

G. Gas Valves: Lubricated plug or AGA-approved ball valves.

H. Clean Steam: 316 stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. General Duty Valve Applications: The drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff duty: Use valve type as indicated on drawings and in this section.
   2. Throttling duty: Use globe (steam only) and plug (heating and chilled water).

B. Install shutoff duty valves at each branch connection to supply mains, at supply mains, at supply connection to each piece of equipment and elsewhere as indicated.

C. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, elsewhere as indicated.

D. Install plug valves on the outlet of each heating or cooling element and elsewhere as required to facilitate system balancing.

E. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage. Provide 1/2-inch ball valves with chain end cap at all tops of risers to be used for venting.

F. Install check valves on each pump discharge and elsewhere as required to control flow direction.

G. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.
H. Install safety relief valves on hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 1 for installation requirements.

I. Install pressure reducing valves on hot water generators, and elsewhere as required to regulate system pressure.

J. Install valves with stems upright or 45 degree maximum, never inverted. When and if steam valves have to be mounted inverted they shall have a valve bonnet drain.

K. Mount all valves so operation is possible without interference from pipes, pipe hangers, walls, etc.

L. Valves (4 inches and larger) located more than 7 feet above floor in mechanical equipment rooms shall be chain operated.

M. Install valves easily accessible. Provide access panels when it becomes necessary to install valves above gypsum ceilings.

END OF SECTION 23 05 23
SECTION 23 05 53 - IDENTIFICATION FOR PIPING AND EQUIPMENT

PART 1 - GENERAL (NOT USED)

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Identification Devices:
      a. Seton Name Plate Company
      b. Marking Services, Inc.
      c. National Marker Co.
   2. Paint:
      a. Benjamin Moore
      b. Devoe
      c. Glidden

2.2 MATERIALS, GENERAL

A. Plastic Pipe Markers
   1. Pipe labels that adhere to pipe or insulation surface with directional arrows.

B. Tags:
   1. Engraved anodized aluminum or engraved plastic, 2-inch diameter. Pre-punched and provided with brass chain.

C. Labels and Nameplates:
   1. Laminated three-layer plastic with black engraved letters on light contrasting background color, drilled for mounting with two sheet metal or brass screws. Pressure-sensitive embossed labels are not acceptable.

D. Paint Stencils:
   1. Use metal stencils only. No cardboard stencils are allowed.
      a. Size of Legend and Letters for Stencils:
         
         | Insulation or Pipe Diameter | Length of Color Field | Size of Letters |
         |-----------------------------|-----------------------|-----------------|
         | 3/4” to 1-1/4”               | 8”                    | 1/4”            |
         | 1-1/2” to 2”                | 8”                    | 3/4”            |
         | 2-1/2” to 6”                | 12”                   | 1-1/4”          |
         | Ductwork & Equipment        | N/A                   | 2-1/2”          |

E. Paint:

F. Underground Plastic Line Markers:
   1. Multi-ply tape consisting of solid aluminum foil core between 2 layers of plastic tape, not less than 6-inches wide x 4 mils thick.

G. Valve Schedule Frames:
   1. Provide frames of finished hardwood or extruded aluminum, with non-glare glass.

PART 3 - EXECUTION
3.1 INSTALLATION, GENERAL

A. Provide pipe identification, valve tags, stencils, or engraved name plates to clearly identify all mechanical equipment, including motors, piping and controls of the various mechanical systems and direction of flow in piping.

B. Plastic Pipe Markers
1. On bare pipe when surface temperature exceeds 180 degree F provide a 1-inch thick insulation band under marker for protection from the hot pipe.

C. Piping, Ducts, and Equipment Identification:
1. Piping:
   a. Identify all piping accessible for maintenance in crawl spaces, tunnels, above ceilings, and access spaces as well as exposed to view utilizing stenciled markings according to the following procedures:
      1) Use an arrow marker for each pipe-content legend. The arrow shall always point away from the pipe legend and in the direction of flow. Color and height of arrow to be same as content legend lettering.
      2) If flow can be in both directions, use a double-headed arrow indication.
      3) Apply pipe legend and arrow indication at every point of pipe entry or exit where line goes through wall or ceiling cut.
      4) Apply pipe legend and arrow indication within 3 inch of each valve to show proper identification of pipe contents and direction of flow.
      5) Apply legend to the pipe so that lettering is in the most legible position. For overhead piping, apply legend on the lower half of the pipe where view is unobstructed, so that legend can be read at a glance from floor level.
      7) Legend on steam piping, condensate return, compressed air, gas, and vacuum systems: Include working pressure or vacuum.
   b. Valves:
      a. System service valves located inside the building: Tag and identify as to type of service.
      b. Valves or cocks controlling branch mains or risers to various portions of the building: Tag and identified as to service and location.
   c. Controls:
      a. Magnetic starters and relays: Install nameplates or stencil to identify connecting or controlled equipment.
      b. Manual operating switches, fused disconnect switches and thermal over-load switches which have not been specified as furnished with indexed face plates: Install nameplates or be stencil as to controlled equipment.
      c. Automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays, and starters: Clearly identified with unit served and function.
      d. Identify all starters, disconnect switches, and manually operated controls, except integral equipment switches with nomenclature corresponding to operating instructions in the "Operation and Maintenance Manual". Coordinate with the university Facilities Operations personnel through the university Project Manager.
   d. Fans:
      a. Label exhaust fans, air handling units and connecting ductwork supplying one or more areas from an equipment room or isolated crawl or furred space. Install nameplate or stencil as to plan code number, service and areas or zones served.
   e. Pumps:
      a. Identify as to service and zones served.
      b. Install nameplate or stencil system served on base mounted pumps.
      c. Install brass tags secured by tie wires on small in-line pumps.
   f. Storage Tanks, Water Treatment Equipment and Heaters:
      a. Stencil service on tanks and heaters
b. Label connecting pipes and indicate the service temperature entering and leaving the tank or heater.

7. Air Conditioning Equipment:
   a. Equipment such as chillers, pumps, condensers, or rooftop equipment: Identified by stencils, or system nameplates. Labels of remote equipment shall also indicate the space(s) being served and the location of their electrical breaker (Panel ID, Room No. And Circuit).
   b. Identify locations of air handling devices which have filters and are above accessible ceilings by a blue circular dot or tack at least 3/4 inch in diameter, or embossed tape, adhered to the nearest T-bar.

8. Access Doors:
   a. Provide engraved nameplates or painted stencils to identify concealed valves, controls, dampers or other similar concealed mechanical equipment.
   b. Identify the locations of fire dampers above accessible ceilings with a red circular dot at least 3/4 inch in diameter, or embossed tape, adhered to the nearest T-bar. Access door shall be painted red.
   c. Obtain the university Project Manager’s approval before installation on all access doors in finished areas.

9. Lift-Out Ceilings:
   a. Provide engraved nameplates on ceiling tee stem (screwed or riveted, adhesive not allowed) to identify concealed valves, filters, fire/smoke dampers or similar concealed mechanical equipment that is directly above nameplate in ceiling space.
   b. Obtain the university Project Manager’s approval before installation.

10. Terminal Units:
    a. Identify all units with unique numbers corresponding to the drawings, and indicate the space being served.
    b. Use engraved plastic laminate labels affixed to each box by screws or rivets.

3.2 SCHEDULES

A. Piping Identification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Color of Field</th>
<th>The Campus Letters</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Inherently Hazardous:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable or Explosive:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Black</td>
<td>NG</td>
</tr>
<tr>
<td>Lab Waste</td>
<td>Yellow</td>
<td>Black</td>
<td>AW</td>
</tr>
<tr>
<td>Extreme Temperatures or Pressures:</td>
<td>Yellow</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Yellow</td>
<td>Black</td>
<td>Dom HW</td>
</tr>
<tr>
<td>Domestic Hot Water, Circulating</td>
<td>Yellow</td>
<td>Black</td>
<td>Dom HWC</td>
</tr>
<tr>
<td>Heating Water Supply</td>
<td>Yellow</td>
<td>Black</td>
<td>HWS</td>
</tr>
<tr>
<td>Heating Water Return</td>
<td>Yellow</td>
<td>Black</td>
<td>HWR</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
<td>LPS</td>
</tr>
<tr>
<td>Low Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
<td>LPSC</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
<td>HPS</td>
</tr>
<tr>
<td>High Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
<td>HPSC</td>
</tr>
<tr>
<td>Boiler Feed Water</td>
<td>Yellow</td>
<td>Black</td>
<td>BFW</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>Yellow</td>
<td>Black</td>
<td>REF</td>
</tr>
<tr>
<td>High Pressure Compressed Air (over 90 psig)</td>
<td>Yellow</td>
<td>Black</td>
<td>CA</td>
</tr>
<tr>
<td>Materials of Inherently Low Hazard:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid or Liquid Admixture:</td>
<td>Green</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>Distilled Water</td>
<td>Green</td>
<td>White</td>
<td>DW</td>
</tr>
</tbody>
</table>
### IDENTIFICATION FOR PIPING AND EQUIPMENT

#### Classification | Color of Field | The Campus Letters | Legend
---|---|---|---
Domestic Cold Water | Green | White | Dom CW
Sanitary Sewer | Green | White | SAN
Waste Vent | Green | White | V
Chilled Water Supply | Green | White | CWS
Chilled Water Return | Green | White | CWR
Condenser Water Supply | Green | White | CS
Condenser Water Return | Green | White | CR
Gas or Gaseous Admixture: | Blue | White |
Medium Pressure Compressed Air (30 to 90 psig) | Blue | White | CA
Low Pressure Compressed Air (less than 30 psig) | Blue | White | CA
Vacuum | White | Black | VAC
Fire Quenching Materials: | | |
Fire Lines | Red | White | FL

#### B. Mechanical Equipment Naming Strategy:
1. Equipment identification numbers may be up to 32 characters. Equipment naming strategy is:
   System – Bld – Number
   ###-#####-##-###
2. The first three placeholders are reserved for the system designation (alpha characters)
3. The fourth character is a hyphen
4. The fifth through ninth placeholders are reserved for the building designation (alpha and/or numeric)
5. The tenth character is a hyphen
6. The eleventh through sixteenth placeholders are a “smart number.” It is composed of a two-digit, alpha or numeric, floor location designator followed by a hyphen and a three digit numeric sequential indicator.
7. The seventeenth character is a hyphen
8. In some instances the point name will be followed by a hyphen and a sub-point name
9. All device and point names will be assigned by the Facilities Operations, Building Operations Department.
10. All references to equipment and devices in drawings, labels, equipment tags, BAS system, etc., must use this naming convention.
11. Equipment designation, for prints may exclude the building designator.

**END OF SECTION 23 05 53**
SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Require general, mechanical and electrical contractors to coordinate and cooperate with the TAB contractors as necessary to allow them to perform work.

B. Items such as start-up, initial testing, cleaning, calibration of controls, electrical testing, etc., are to be completed prior to the commencement of TAB work.

C. Submit name of balancing and testing agency with resume of the agency, including qualifications of personnel to be used and authority and responsibilities of personnel.

D. Product data shall be submitted, in accordance with Section 23 00 00, for each of the following:
   1. Procedure Submittal: Prior to commencing work, submit, for approval, a written procedure of how balance will be performed and a description and manufacturer’s name of equipment and instruments to be used. The submittal shall include, but not necessarily be limited to the following:
      a. List of preliminary checks to be performed at the job site such as confirmation that manual volume dampers are present, filters are installed, frequency drive units operational, location of control sensors, etc.
      b. Identify how the air outlets will be measured and the type of instruments to be used.
      c. Locations of pilot traverses and the type of instruments to be used.
      d. Modes of operation that the system will be placed in during balancing and testing, i.e., full cooling and heating, maximum and minimum outside air flows, maximum and minimum sash positions for fume hoods, toilet fans on or off, etc.
      e. Position of doors and windows during balance, i.e., some labs should be balanced with doors shut.
      f. Operating static pressures for terminal devices and pressure sensors for controlled devices.
      g. Method of adjusting outside and return air quantities at air handling units.
      h. Initial test procedures for preliminary balance.
      i. Final test procedures.
      j. List of deficiencies in mechanical system that could hinder the balance work such as missing or leaky dampers, incomplete systems, inadequate fans, etc.
      k. Sample of data sheets and test forms to be used in final report.
      l. Identification and manufacturer's name of equipment to be used on project and proof of last calibration on each piece.
   2. Progress Report(s) – Report, in writing, any deficiencies or problems with air or water systems that have affected balance work. Include items that affect system performance such as broken thermostats, damaged ductwork, excessive noise, etc.

1.2 QUALITY ASSURANCE


B. TAB contractors shall present to the University Project Manager and general contractor, proof of current equipment certification approved by National Institute of Standards and Technology.
C. Testing Agency Qualifications: Agency shall be NEBB or AABC certified in testing and balancing disciplines required for this project. Work shall be performed under direct supervision of professional engineer, NEBB, or AABC certified supervisor.

D. Guarantee of Work: TAB contractor shall guarantee the balancing for a period of 90 days from date of acceptance of final report. During this period, the TAB contractor shall make personnel available at no cost to the university to verify measurements and/or correct deficiencies in the balance. During this period, emergency adjustments shall not void this warranty.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Pre-Balancing Conference: Before beginning testing, adjusting, and balancing procedures, schedule and conduct a conference with University Project Manager, Facilities Operations Representative(s) and representatives of installers of mechanical and control systems. Conference objective is final coordination and verification of system operation and readiness for testing, adjusting, and balancing, and assigning testing responsibilities of each installer.

B. Systems shall be complete and fully operational prior to beginning procedures. Insure all items such as thermometer wells, pressure test-cocks, access doors, etc., are installed to facilitate tests and adjustments.

C. Put all heating, ventilating, and air conditioning systems and equipment into full operation and continue operation during testing and balancing.

D. Before air balance work is started, check system for duct leakage, install a complete set of clean filters, check for correct fan rotation and equipment vibration, and check automatic dampers for proper operation. Set volume control dampers and outlets in wide open position. Ensure fire dampers are open and that return air paths are not obstructed.

E. Prior to performing hydronic balance work; check system for plugged strainers, proper pump rotation, and proper control valve installation and operation. Check air vents at high points of systems to ensure all are installed and operating freely (automatic type) or bleed air completely (manual type); and verify proper flow meter and check valve installation and proper system pressure.

F. All throttling devices and control valves shall be set open.

G. Performing Testing, Adjusting, and Balancing:
   1. Cut insulation, ductwork, and piping for installation of test probes to minimum extent necessary to allow adequate performance of procedures.
   2. Patch insulation, ductwork, and housings, using materials identical to those removed.
   3. Reseal ducts and piping, and test for and repair leaks.
   4. Reseal insulation to re-establish integrity of the vapor barrier.
   5. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other permanent identification materials.
   6. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

H. Sequencing and Scheduling:
   1. Systems shall be fully operational before beginning procedures.
2. Conduct tests in the presence of the University Project Manager after providing 7-day notice before any test is to be conducted. Provide water and electricity required for tests. Determine that all dampers, registers, and valves are in a set or full open position.

I. Balancing:

1. Water Balance:
   a. Balance water piping and snow melt systems to produce water quantities within 5 percent of design flow rates for cooling water systems and within 10 percent of design flow rates for heating water systems.
   b. Hydronic systems shall be proportionally balanced, ensuring the path to one terminal is fully open. Total system flow shall be adjusted at pump by restricting discharge balancing valve.
   c. Indicate and record final position of balancing valves.
   d. Primary-Secondary Flow Systems: Balance primary system crossover flow first, then balance secondary system.

   e. Pumps:
      1) Verify pump impeller size and pump rotation.
      2) Measure flow.
      3) Measure inlet and outlet pressures.
      4) Measure motor full load amperage at design flow and shut-off condition.

   f. Heat Exchangers:
      1) Measure water flow through all circuits.
      2) Measure inlet and outlet water temperatures.
      3) Calculate capacity in btu-h.
      4) Measure inlet steam pressure. Check setting and operation of automatic temperature-control valves and pressure reducing valves.
      5) Record safety valve settings.
      6) Verify operation of steam traps.

   g. Chillers:
      1) Balance water flow through each evaporator and condenser with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed flow for maximum tube velocity recommended by chiller manufacturer. Perform tests and record data with each chiller operating at design conditions for:
         a) Evaporator and condenser water entering and exiting temperatures, pressure drop, and water flow.
         b) Evaporator and condenser refrigerant temperature and pressures.
         c) Calculate capacity in tons.
      2) For air cooled chillers, verify condenser fan rotation and record fan data, including number of fans and entering and exiting air temperatures.

   h. Cooling Towers:
      1) Shut off makeup water for duration of test and ensure makeup and blow-down systems are fully operational after tests. Perform tests and record data for:
         a) Condenser water flow to each cell of cooling tower.
         b) Entering and exiting water temperatures.
         c) Wet, and dry, bulb temperatures of entering and exiting air.
         d) Condenser water flow rate recirculating through cooling tower.
         e) Cooling tower pump discharge pressure.
         f) Fan cfm and static pressure for each cell.

   i. Heat Transfer:
      1) Measure entering and exiting water temperatures and pressures.
      2) Measure gas flow rate.
      3) Measure water flow.
      4) Calculate capacity in btu-h.

   j. Water Coils:
      1) Measure entering and exiting water temperatures and pressures.
      2) Measure water flow rate.
3) Measure entering and exiting dry, and wet, bulb air temperatures.
4) Measure airflow. Measure air pressure drop. Calculate capacity in btu-h.

k. Finned Tube Radiation:
1) Measure entering and exiting water temperatures.
2) Measure water flow rate.
3) Calculate capacity in btu-h.

l. Evaporative cooling:
1) Adjust water flow across media per manufacturer.
2) Adjust bleed rates.
3) Adjust fill rates.

2. Air Balance:
a. Balance duct system to produce air quantities within 10 percent of indicated value.
b. Dampers: Adjust automatic damper linkages to provide air flow quantities shown. Check all automatic dampers in normal operation to verify proper operation. Verify return, relief air, and fresh air intake dampers operate as designed to produce desired room comfort.
c. Place all fans (supply, return, and exhaust) in operation. Load or restrict filters to increase pressure drop to 50% of span between initial pressure drop and final recommended pressure drop for setting final air flows for fans. Check the following:
1) Motor amperage and voltage to guard against overload.
2) Fan rotation.
3) Operability of static pressure limit switch.
4) Automatic dampers for proper position.
5) Air and water resets operating to deliver required temperatures.
6) Air leaks in casing and in safining around coils and filter frames.
d. Traverse Main and Branch Ducts: Perform pitot traverses for fan total air flows including traverses for hot and cold decks, for each zone in multi-zone systems and for each floor. Mark locations of pitot traverses on reduced drawings in final report.
1) Note temperature and barometric pressure. Corrections shall be made for systems operating at 5200-foot elevation.
2) After establishing total air being delivered, adjust fan speed to obtain design airflow. Check power and speed to see that motor power and critical fan speed have not been exceeded.
3) Proportionally adjust branch dampers until each has proper air volume.
4) With all dampers and registers in system open and with supply, return, and exhaust fans operating at design cfm or speed, set minimum outdoor and return air ratio.
5) After minimum outside air damper has been set for proper percentage of outside air, take another traverse of mixture temperatures. Notify the University Project Manager and note in balancing report if variation from average is more than 5 percent.
e. Adjust system with mixing dampers positioned for minimum outside air.
f. Balance terminal outlets in each control zone in proportion to each other. Use branch dampers for major adjusting and terminal dampers for trim or minor adjustment only.
g. Balance constant volume reheat systems in one mode, namely design airflow.
h. Balance constant volume dual duct systems at the boxes for full cooling and full heating air flows. Balance the fan with all the boxes on full cooling. Record the total fan supply with the boxes on full cooling.
i. Balance VAV fans by placing a certain number of the VAV boxes in full cooling mode. This number shall be equal to the system diversity and shall include boxes that are at the end of the system, that are on duct branches with high static loss and serve critical areas. With the system in this mode the fan shall be sheaved to maintain the static pressure required to control the worst case VAV box.
j. Once total design air has been balanced in branches and at outlets, verify and record the following:
1) Fan motor amperage.
2) Fan speed
3) Fan cfm.
4) Fan outlet velocity.
5) External and total static pressure.
6) Supply, return, mixed, and outside air temperatures.
7) Percent outside air under minimum damper position.
8) Static pressure across each component (intake, filters, coils, and mixing dampers).
9) Take a final duct traverse.

k. Final adjustments shall include, but not be limited to the following:
1) Adjust RPM on belt drive fans. Include sheave and belt exchange to deliver air flow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for filter loading and shall establish proper duct pressures for operation of zone cfm regulators.
2) Replace all variable pitched sheaves with fixed pitched sheaves. This includes such devices as fan coils.
3) Adjust rpm on Direct Drive Fans:
   a) For motors with speed taps, set fan speed on tap which most closely approaches design cfm. Report tap setting on equipment data sheet as high, medium, or low.
   b) For motors with speed control, set output of fan at design cfm by adjusting control. Ensure the fans restart after shut down. Increase setting as required for proper setting. Mark control to indicate final setting position.
4) Terminal Boxes:
   a) For variable air volume (VAV), constant volume boxes, or dual duct boxes, set regulators to provide design minimum and maximum airflow rates. Adjust thermostat to assure proper damper operation.
   b) For VAV, or constant volume boxes with reheat, set regulators to provide design minimum and maximum air flow rates. Check control sequence operation to assure proper sequencing.
   c) Air flow performance of boxes for both primary and secondary balance settings shall be verified by flow measuring hood measurements at diffuser outlets.

3. Fume Hood Balancing:
   a. Balance fume hood exhaust fans to meet face velocity requirements. The face velocity shall be maintained at a face velocity as required by the project specific equipment, the manufacturer and coordinated with the University Project Manager and EH&S.
   b. Balance hoods with the building supply and exhaust systems in normal operation, with doors and windows in typical position and hoods empty and clean. Record these conditions in report.
   c. Set horizontal sash hoods at 12 inches or greater. Adjust the fan to provide the required face velocity measured at a minimum of nine centerline measurements equally spaced at sash plane using a hot wire anemometer. The average of the nine measurements shall be corrected for temperature and altitude and recorded. Place a sticker furnished by the University Project Manager at the approved sash height.
   d. Raise the sash to find the height where the design face velocity is achieved. Mark this height with a second sticker furnished by the University Project Manager. If the sash height is below the acceptable working height, the hood will not pass acceptance.
   e. Set vertical sash hoods with a 12-inch or greater space centered in front of the hood. If an odd number of sashes exist, the opening shall be the most distant from the exhaust point inside the hood. Adjust the fan to provide the required face velocity measured at a minimum of nine centerline measurements equally spaced at sash plane using a hot wire anemometer. The average of the nine measurements shall be corrected for temperature and altitude and recorded.
   f. Move the sash to find the position where the design face velocity is achieved. Mark this position with a second sticker furnished by the University Project Manager.
   g. Indicate face velocity in FPM on fume hood for record.
h. Adjust spaces with pressure gradients or directional air flow requirements to meet standards as well as designated air flows. Verification of performance shall be made with pressure gradient measurements, smoke tests in presence of the university Facilities Operations representative, or hot wire anemometer across door cracks etc. Pressure differential measurements are preferred unless gradient is too small (under 0.01 inches w.c.) by standard.

i. Hoods to be tested and balanced in accordance with ASHRAE 110 and SEFA Standards.


5. Smoke Systems: Test smoke management systems per NFPA 92A.

6. Equipment Motors: Record the following information for every motor and include information with the appropriate equipment.
   a. Motor horsepower and rpm.
   b. Nameplate and measured voltage and amperage, each phase.

   a. Verify proper operation of devices. Verify that all controllers are calibrated and operational.
   b. Check location of transmitters and controllers. Note adverse conditions that would affect control and suggest relocation as necessary to University Project Manager.
   c. Note settings on controllers. Note discrepancies between set point for controller and actual measured variable.
   d. Verify operation of all limiting controllers, positioners, and relays (e.g., high and low temperature thermostats, high and low differential pressure switches, etc.).
   e. Activate controlled devices, checking for free travel and proper operation of stroke for dampers and valves. Verify and note normally open (NO) or normally closed (NC) operation.
   f. Verify sequence of operation of controlled devices. Note line pressures and controlled device positions. Correlate to air or water flow measurements. Note speed of response to step change.
   g. Confirm interaction of interlock and lockout systems.
   h. Provide set-point for every hydronic and air system pressure sensor. Coordinate closely with Division 23 09 00.
   i. Provide differential pressure set-point for dirty filter replacement for each filter bank installed in the building.

8. Sound and Vibration Levels: Test and adjust mechanical systems for sound and vibration in accordance with instructions of referenced standards.

9. Provide baseline acoustical and vibration testing for all air handlers, and large exhaust fans.

10. After deficiencies are corrected, retest the systems until acceptable values are obtained.

11. Permanently mark balancing devices spray paint indicating final position. Grease markers are not permitted.

J. Report:
   1. Report Format: Standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Include information indicated on standard report forms prepared by AABC or NEBB for each respective item and system, and schematic diagrams for each system or piece of equipment to accompany each respective report form. Bind report forms complete with schematic systems diagrams and other data in reinforced vinyl three-ring binders. Provide binding edge labels with project identification and a title descriptive of contents. Divide contents of binder into following divisions, separated by divider tabs:
      a. General Information and Summary
      b. Air Systems
      c. Hydronic Systems
d. Temperature Control Systems
e. Special Systems such as fume hood exhaust systems.
f. Sound and Vibration Systems
g. Recommendations.

2. Report Contents: Provide following minimum information, forms, and data:
   a. General Information and Summary:
      1) Inside cover sheet to identify testing, adjusting, and balancing agency, contractor, and project name. Include contact names, addresses, and telephone numbers.
      2) Certification sheet containing seal, address, telephone number, and signature of Certified Test and Balance Engineer.
      3) Listing of instrumentation used for procedures along with proof of calibration.
   b. Test Data: Report shall include the following data, in addition to certified field report readings taken during the balancing and testing operations. Include required or specified reading, first reading taken, and final balanced reading.
      1) Air Handling Units and Fans: Air handling unit, fan and motor nameplate information, type, drive sheave information (as installed and changed), and final belt number and size.
      2) Air Balance for Supply, Return, Relief, and Exhaust Systems:
          a) Outlets, Inlets, Diffusers, Registers, and Grilles: Size, reading orifice size, velocity in fpm, and design and final balanced air quantity in cfm.
          b) Terminal Boxes: Design and final minimum and maximum cfm settings including fan cfm on fan powered terminal boxes.
          c) Ducts: Size, velocity in fpm, and air quantity in cfm.
      3) Hydronic Balance:
          a) Water coil size and manufacturer.
          b) Boiler and burner nameplate information and flue gas analysis. Flue gas analysis shall be copy of manufacturer's analysis report.
          c) Chiller and motor nameplate information.
          d) Cooling tower and fan motor nameplate information.
          e) Pump and motor nameplate information. Include manufacturer's pump curves.
          f) Heat exchanger nameplate information.
          g) Snow melt circuits.
      4) Record thermal protection for all motors. Starter brand, model, enclosure type, installed thermal heaters and rating of heaters, required thermal heaters and rating of heaters if different from installed shall be recorded.
      5) Include sheet that reports method of balance, project altitude, and any correction factors used in calculations.
      6) Include a reduced set of contract drawings with all terminals (VAV boxes, outlets, inlets, coils, unit heaters, fans, etc.) clearly marked and all equipment designated.
      7) Prepare list of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.2 TESTING, CLEANING AND CERTIFICATION

A. After cleaning, pressure tests, adjusting, and balancing are complete, each system shall be performance tested as a whole to verify that all items perform as integral parts of system, and temperatures and conditions are evenly controlled throughout building. Make corrections and adjustments as required to produce conditions indicated.

B. Provide four (4) copies of testing, adjusting, and balancing report bearing seal and signature of the TAB Engineer. The report shall be certification that systems have been tested, adjusted, and balanced in accordance with referenced standards; accurate representation of how systems have been installed; and accurate record of all final quantities measured.

C. Final Report:
1. Submit a preliminary report within 30 days of completed TAB work. Report shall include the following information.
   a. A general discussion preface section. This section shall summarize all abnormalities or problems encountered during the project and what course of action was taken. This summary should be assembled from the written progress reports described earlier, except that it will be expanded to include responses from the Engineer, the University Project Manager and Contractor regarding each problem indicated in the progress reports.
   b. Copies of correspondence if related to the performance and balance of the systems.
   c. Status of doors, windows and equipment static pressures during balance work.
   d. Reduced 11" x 17", readable, as-built drawings obtained from the University Project Manager. All devices and equipment shall be clearly labeled.
   e. Belt and sheave information, fan and motor nameplates information, full load operating voltage and amperage indicate sheave diameter as pitch diameter.
   f. Design and final actual cfm at each system terminal unit. Include terminal/size, inlet static pressure, temperature and velocities read to attain the design cfm.
   g. Overload protection for all motors shall be recorded. Starter and brand model, enclosure type, installed overload devices, original ratings, and set points (and revised device ratings and set points when application) shall be recorded.

2. Any corrective action shall be completed and the systems re-tested. The corrected system information shall be provided in the final report.

3. Final Report shall be completed within 30 days of preliminary report.

3.3 COMMISSIONING (DEMONSTRATION)

A. Upon request of the university Facilities Operations Representative, through the University Project Manager, the balancing firm shall demonstrate measured quantities of randomly selected equipment. The number of readings verified will not exceed 10 percent of the total in the report.

END OF SECTION 23 05 93
SECTION 23 07 00 – INSULATION

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Provide minimum insulation thickness as suggested in ASHRAE Standard 90A.

B. Provide removable insulation for chilled water pumps and specialty valves and fittings.

1.2 DEFINITIONS

A. Concealed: As used in this Section refers to insulation in ceiling plenums, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, unexcavated areas, and crawl spaces.

B. Exposed: As used in this Section refers to insulation that is not concealed.

1.3 QUALITY ASSURANCE

A. Composite insulation, including jackets, coverings, sealers, mastics, and wet or dry adhesives shall have a flame spread rating of 25 or less and smoke-developed rating of 50 or less, as tested by ASTM E84.

B. Elastomeric foam with a smoke-developed rating of 150 or less may be used, except in ducts, plenums, and concealed spaces that are part of the air distribution system.

C. PVC fitting covers shall have a maximum flame spread of 25 or less and are exempted from the smoke spread criteria.

D. Duct liner shall comply with NAIMA Fibrous Glass Duct Liner Standard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Insulation: Identification and/or type of material from a manufacturer is as shown under each heading of 2.2 Materials, General.
   a. Manville Products
   b. CertainTeed
   c. Rubatex
   d. Knauf
   e. Pittsburgh Corning

2. Adhesives, Coatings, and Sealants:
   a. Foster
   b. Childers Product Company
   c. Hardcast

2.2 MATERIALS, GENERAL

A. Pipe Insulation:

1. Glass Fiber:
   a. Manville Micro Lok AP T Plus

2. Hydrous Calcium Silicate:
   a. Rigid, molded block, conforming to ASTM C533.
b. Asbestos-free, color-coded throughout material. Coding shall remain stable throughout rated temperature range.
c. Thermal Conductivity (k Value): 0.40 at 300 degrees F.
d. Maximum Service Temperature: 1,200 degrees F.
e. Compressive Strength: Minimum of 160 PSI to produce 5% compression at 1-1/2 inch thickness.
f. Tie wires: 16 gauge stainless steel.
g. Manville Thermo 12/Gold

3. Elastomeric Foam:
   a. Flexible, cellular, molded or sheet; conforming to ASTM C534.
   b. Thermal Conductivity (k value): 0.27 at 75 degrees F.
   c. Maximum Service Temperature: 220 degrees F.
   d. BBX, K-Flex acceptable for high temp applications to 300 deg F.
   e. Connection Adhesive: Waterproof, vapor retarding, Rubatex R-373.
   f. UV protective coating: Water-based latex enamel paint. Rubatex 374.
   g. Insulation Tape: Elastomeric thermal insulation tape with closed-cell structure.
   h. Rubatex R-180-FS/R-1800-FS.

4. Cellular Glass:
   a. Waterproof, closed cell, rigid insulating material composed of sealed glass cells conforming to ASTM C552.
   b. Thermal Conductivity (k value): 0.35 at 75 degrees F.
   c. Density: 8 pounds per cubic foot.
   d. Water-vapor Permeability: 0.005 perm-inch.
   e. Pittsburgh Corning Foamglass.

B. Field Applied Pipe and Fitting Jacketing:
   1. PVC Plastic: One-piece, UV-resistant, 20-mil thick, molded type, gloss white finish with fiberglass insulation insert for fittings.
      b. Manville Zeston 300 (outdoors).
   2. Aluminum:
      a. 0.016-inch thick sheet with smooth or embossed finish, longitudinal slip-joints with 2-inch laps.
      c. Fitting covers: Die shaped with factory attached protective liner.
   3. Canvas:
      a. Plain weave cotton treated with fire-retardant lagging adhesive.
      b. Weight: 6 ounces per square yard.
      c. UL listed fabric.
   4. Stainless Steel:
      a. 0.010-inch thick, type 304 stainless steel with smooth or corrugated finish.

C. Duct Insulation:
   1. Flexible Fiberglass Blanket:
      a. ASTM C553, Type 1, Class B-3.
      b. Thermal Conductivity (k value): 0.25 at 75 degrees F.
      c. Density: 1.0 pounds per cubic foot.
      d. Vapor barrier jacket: Aluminum foil reinforced with fiber-glass yarn and laminated to fire-resistant Kraft (Foil Scrim Kraft).
      e. Manville Microlite.
   2. Rigid Fiberglass Board: Not allowed.
   3. Interior duct lining allowed only for sound attenuation at ventilation system terminal units. Insulation shall be installed only on the leaving side of the terminal box, and in quantities of less than six lineal feet.

D. Duct Jacketing:
1. **Canvas:**
   a. Plain weave cotton treated with fire-retardant lagging adhesive.
   b. Weight: 6 ounces per square yard.
   c. UL listed fabric.

2. **Outdoor Duct Jacketing:**
   a. Aluminum: 0.016-inch thick sheet with smooth or embossed finish, longitudinal slip joints with 2-inch laps.
   b. Non water-vapor retarder: Non-burning, weatherproof coating, Manville Insulkote ET.
   c. PVC plastic: 30mil thickness, UV resistant, Manville Zeston, 300 Series.

E. **Duct Liner** (allowed for sound attenuation only, 6 lineal feet, at leaving side of terminal units. Duct liner is not allowed in lab air supply):
   1. **Round Duct Liner:**
      a. Rigid material, conforming to ASTM C427.
      b. Thermal Conductivity (k value): 0.23 at 75 degrees F.
      c. Noise Reduction Coefficient: ASTM C423, minimum of 0.70 based on type-A mounting.
      d. Velocity rating: Minimum of 4,000 feet per minute.
      e. Manville Spiracoustic.

F. **Equipment Insulation:**
   1. **Flexible Fiberglass Blanket:**
      a. ASTM C612, Class 1.
      b. Thermal Conductivity (k value): 0.24 at 75 degrees F.
      c. Maximum Service Temperature: 450 degrees F.
      d. Density: 1.5 pounds per cubic foot.
      e. Vapor Retarder Jacket: Aluminum foil reinforced with fiber glass yarn and laminated to fire-resistant kraft paper.
      f. Manville 812 Spin-Glass.

2. **Rigid Fiberglass Board:**
   a. ASTM C612, Class 1 or Class 2.
   b. Thermal Conductivity (k value): 0.23 at 75 degrees F.
   c. Maximum Service Temperature: 450 degrees F.
   d. Density: 3 pounds per cubic foot.
   e. Vapor Retarder jacket: Aluminum foil reinforced with fiberglass yarn and laminated to fire-resistant kraft paper.
   f. Facing: 1-inch galvanized hexagonal wire mesh stitched on one face of insulation.
   g. Manville 814 Spin-Glas.

3. **Rigid Fiberglass Board (High Temp):**
   b. Thermal Conductivity (k value): 0.23 at 75 degrees F.
   c. Maximum Service Temperature: 850 degrees F.
   d. Density: 3 pounds per cubic foot.
   e. Facing: 1-inch galvanized hexagonal wire mesh stitched on one face of insulation.
   f. Manville 1000 Spin-Glass.

4. **Cellular Glass:**
   a. ASTM C552.
   b. Thermal Conductivity (k value): 0.35 at 75 degrees F.
   c. Density: 8 pounds per cubic foot.

5. **Hydrous Calcium Silicate:**
   a. Rigid, molded block, conforming to ASTM C533.
   b. Asbestos-free color-coded throughout material. Coding shall remain stable throughout rated temperature range.
   c. Thermal Conductivity (k value): 0.40 at 300 degrees F.
   d. Maximum Service Temperature: 1200 degrees F.
   e. Compressive strength: Minimum of 160 PSI to produce 5% compression based on 1-1/2 inch thickness.
f. Manville Thermo-12/Gold.

G. Tank Insulation:
1. Flexible Fiberglass Board:
   a. Thermal Conductivity (k value): 0.35 at 200 degrees F.
   b. Maximum Service Temperature: 650 degrees F.
   c. Density: 3 pounds per cubic foot.
   d. Vapor Retarder Jacket: Pressure sensitive, self-sealing tape lap system of white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil.
   e. Manville Pipe and Tank Insulation.

H. Steam Valve Insulation:
1. Material:
   a. Insulation: Fiberglass
   b. Inner jacketing: Teflon coated Nomex cloth.
   c. Gussets: Teflon coated Nomex cloth.
   d. Outer jacketing: Teflon coated Nomex cloth.
   e. Sewing Thread: Stainless steel using lock stitch with seven stitches per inch.
   f. Seam Fasteners: Teflon belts with stainless steel double D-rings and Velcro tabs.
   g. Terminal Ends: Teflon coated Nomex cloth flaps with Teflon coated Nomex cloth drawcord.
   h. Hardware: 304 stainless steel.
   i. Maximum Service Temperature: 500 degree F, wet or dry environment.
   j. Secure insulation within the jacketing with stainless steel quilt pins. Secure covers with cinch belts. Teflon belts with two stainless steel D-ring fasteners.
   k. Belts secured to cover with Velcro hook-and loop-fasteners.
   l. Advance Thermal Corporation.

I. Fire-stop Insulation:
1. Flexible blanket, amorphous wool:
   a. Thermal Conductivity (k value): 0.85 at 1000 degrees F and 1.70 at 1800 degrees F
   b. Continuous use-temperature rating: 1834 degrees F
   c. Melting point: 2327 degrees F
   d. Density: 6 pounds per cubic foot.
   e. Thermal Ceramics SF607.

J. Fixed and Removable Valve Insulation:
1. Insulate valves, strainers and other equipment on steam, condensate, and hot water lines.
2. Steam and Hot Water Valves:
   a. 3 inch and larger: Insulate with removable insulation jacket.
   b. 2-1/2 inch and smaller: Do not insulate unless removable type is shown to be cost effective or effect of heat loss is shown to be detrimental.
3. Removable Insulation Jackets:
   a. 1 inch thick fiberglass insulation.
   c. Maximum Service Temperature: 1000 degree F.
   d. Secure with stainless steel quilting pins.
   e. Inner and Outer Jacket: Silicone coated fiberglass, 34 oz. per sq. yard, chemical resistant, suitable for temperatures to 500 degree F.
   f. Seam Closure: Teflon coated fiberglass threads suitable for temperatures to 600-degree F. of type 20 lb. Tensile strength.
   g. Fastening System: Type 304 stainless steel double D-rings with silicone coated fiberglass belts with Velcro on ends. 1-inch wide belt sewn to adjacent insulation, flanges, etc. Stainless steel wire cords, minimum 1/4 inch diameter and Teflon coated.
   h. Identification: Furnish type 304 stainless steel or aluminum I.D. tag riveted to jacket with item description, location and factory number.
K. Utility Vault Pipe Insulation
   1. Steam and condensate line insulation
      a. Closed-cell fiberglass
      b. All insulation surfaces shall be protected by metal jacketing
   2. Chilled water supply and return insulation
      a. Closed-cell fiberglass
      b. Required insulation thickness
      c. All insulation surfaces shall be protected by metal jacketing

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL:

A. Overview:
1. Install insulation only after piping, ducts, and equipment have been tested and approved by the Project Manager, and after all other tests and certifications which are required by the specifications have been satisfactorily completed.
2. Continue insulation vapor barriers through penetrations except where prohibited by code.
3. Install pipe and duct insulation continuous through wall and floor openings except where the penetrated surfaces or assemblies are fire-resistance rated. Provide fire-stop insulation at penetrations of fire-rated surfaces and assemblies. Maintain fire-resistance ratings of penetrated surfaces and assemblies.
4. Install insulation on cold surfaces with a continuous, unbroken vapor seal. Insulate and vapor seal supports and anchors, which are directly secured to cold surfaces.
5. Seal all exposed raw edges of insulation with vapor retarder or finishing cement.
6. Do not use staples on vapor barrier jackets. Where staples must be used, thoroughly seal the vapor barrier penetrations with a white vapor-barrier finish. The Engineer prior to installation must approve use of staples.
7. Do not weld insulation support pins to pressure vessels.
8. Leave all insulation surfaces dry and clean, and ready for subsequent work.

B. Installation of Piping Insulation:
1. Install insulation and covers with seams in the least visible location.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Verify piping wells and P & T taps are extended so that they will be flush with the surface of the finished insulation.
4. Insulated dual-temperature piping systems and for insulated piping conveying fluids of a temperature less than the ambient temperature: Install vapor-retardant jacket with self-sealing lap joints. Insulate the complete systems.
5. Insulated piping conveying fluids of a temperature greater than the ambient temperature: Install vapor-retardant jacket with self-sealing lap joints. Bevel and seal ends of insulation at equipment, flanges, and unions.
6. Piping conveying cold fluids: Insulate continuous through hangers. Install rigid insulation inserts at pipe hangers and supports. Butt inserts tight to insulation. Apply a wet coat of vapor-barrier lap cement on butt joints and seal the joints with three-inch wide vapor-barrier tape or band.
7. Install calcium silicate insert between support shields and piping for piping 1-1/2 inches and larger. Inserts shall not be less than the following lengths:

<table>
<thead>
<tr>
<th>Pipe Size Inches</th>
<th>Insert Length Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2</td>
<td>6</td>
</tr>
<tr>
<td>2 through 9</td>
<td>9</td>
</tr>
<tr>
<td>10 through 14</td>
<td>12</td>
</tr>
<tr>
<td>16 through 24</td>
<td>18</td>
</tr>
</tbody>
</table>
8. Exposed piping in mechanical equipment rooms and exposed piping within 10 feet of the finished floor in finished spaces: Install PVC jacket and fitting covers or aluminum jacket.

9. Exterior applications: Install PVC jacket and fitting covers or aluminum jacket over insulated pipe, fittings, joints, and valves. Locate jacket seams on bottom side of horizontal piping. Cover all valves, flanges, unions, accessories, and fittings with aluminum jacket. Seal jacket watertight and secure with lock type aluminum bands.

10. Refrigerant piping insulated with elastomeric insulation: Seal joints with elastomeric sealant made by same manufacturer as the insulation. For outdoor locations, paint insulation white or silver. Paint shall be compatible with the insulation.

11. Piping under concrete slabs on grade: Spiral wrap insulation with Protecto Wrap 200 coating with 50% overlap. Lay the insulated and wrapped piping on a 3-inch bed of sand and cover with 3 inches of sand all around.

C. Installation of Blanket Insulation:
1. Apply insulation with edges tightly butted. Overlap facing at least two inches at joints. Seal joint in vapor seal with fire-retardant adhesive. Secure insulation to duct with approximately four-inch wide fire-retardant adhesive spaced at 8 inches on center
2. Ducts Exceeding 30 Inches in Width: Install mechanical fasteners at 18 inches on center for the underside insulation in addition to the adhesive. Cut off the protruding ends of the fasteners flush after speed clips are installed and seal with vapor tape or mastic.
3. Insulated ducts conveying air of a temperature less than the ambient temperature: Install vapor retardant jacket. Seal jacket seams and penetrations with UL listed tape or vapor retardant adhesive.
4. Insulated ducts conveying air of a temperature greater than the ambient temperature: Bevel and seal ends of insulation where service access is required.
5. Ducts Subject to Physical Abuse in Mechanical Equipment Rooms and Finished Spaces: Install PVC or aluminum jacket.
6. Outdoor Applications: Install insulation with a weather protection jacket.

D. Installation of Equipment Insulation:
1. Apply insulation as close as possible to equipment. Groove, score, and bevel insulation as necessary to achieve a tight fit. Secure insulation to equipment with studs, clips, pins, adhesive, wires, or bands as appropriate for the application. On cold equipment, do not use securing methods that penetrate the vapor barrier
2. Fill joints, cracks, seams, and depressions with bedding compound. Form smooth surfaces. On cold equipment, use vapor retardant cement.
3. Insulated dual-temperature equipment and for insulated equipment that contains fluids of a temperature less than the ambient temperature: Install vapor retardant jackets.
4. Insulated equipment that contains fluids of a temperature greater than the ambient temperature: Install jacket with or without vapor barrier.
5. Cover insulation with metal mesh and finish with heavy coat of insulating cement, mastic, or aluminum jacket.
6. Do not insulate over nameplates, ASME stamps or UL labels. Bevel and seal insulation around nameplates and labels.
7. When equipment with insulation requires periodic opening for maintenance, repair, or cleaning, install insulation so that it can be easily removed and replaced without damage.

E. Installation of Insulation on Fittings and Valves:
1. Factory premolded one piece PVC insulated fitting covers: Use factory precut insulation applied to the fitting using two layers for pipe temperatures above 250 degrees F or below 35 degrees F, single layer insulation is acceptable between 35 degrees F and 250 degrees F. Tuck the ends of the insulation snugly into the throat of the fitting and the edges adjacent to the pipe covering, tufted and tucked in, fully insulating the pipe fitting. Covers shall overlap the adjoining pipe insulation and jackets, and on cold pipes seal at all seam edges with vapor barrier adhesive. Seal circumferential edges of all covers with pressure sensitive vinyl tape. The tape shall overlap the jacket and the cover at least one inch.
2. Where PVC covers are prohibited: Use as an alternate one of the following methods: aluminum covers, one coat insulation cement, premolded fiberglass fitting covers, or mitered segments of pipe insulation. Finish for non-PVC or aluminum shall be glass fabric embedded in fire retardant mastic lapped 2 inches over piping insulation. Finish with second coat of mastic. Mastic shall be vinyl acrylic mastic Childers CP-11 for hot piping and shall be Childers CP-30 or Fosters 30-35 or equal for cold piping.

3. Valves may be insulated with sections of fiberglass pipe insulation complete with All Service Jacket. Raw ends shall be coated with vinyl acrylic mastic Childers CP-11 for hot piping or shall be coated with vapor barrier mastic Childers CP-30 or Fosters 30-35, or equal for cold piping.

4. Insulate balancing cocks, strainer drains, hose bibs, and equipment requiring periodic maintenance with segmental insulating with an integral vapor barrier. Insulation and vapor barrier shall be easy to remove and replace.

F. Installation of Engine Exhaust and Breeching Insulation:
1. Install calcium silicate insulation on engine exhaust and breeching.
2. Install two layers of calcium silicate. Tightly butt and stagger joints. Secure with 16-gauge galvanized or stainless steel wire, or 1/2-inch by .015-inch galvanized steel bands. Install supports 12 inches maximum on center.

G. Installation of Tank Insulation:
1. Wrap insulation around tank and secure with self sealing longitudinal laps and butt strips, or all-purpose jacket with outward clinch expanding staples on maximum 4-inch centers. Remove two segments of insulation to provide for lap.
2. Cut circular sections for top and bottom of tank and insert inside of tank wrap.
3. Seal all longitudinal and circumferential joints with 3 inches wide pressure sensitive tape.
4. Apply vapor retarder mastic to all joints and staples.

H. Installation of Fire-stop Insulation:
1. Install per listing.

I. Installation of Steam and Hot Water Valves Insulation:
1. Provide custom fabricated insulated jackets for all valves and fittings.
2. Fabricate inner and outer jacketing for exposure to steam leaks on medium and high-pressure steam systems. Jacketing shall retain full flexibility after an exposure from minus 50 degrees F to plus 500 degrees F.
3. Construct and install covers to shed water. Locate closing seams at the gravitational bottom. Closely contour removable covers, ensure neat appearance and thermal performance. Individual covers or cover sequents shall not weigh more than 60 pounds.

END OF SECTION 23 07 00
SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the commissioning process for facilities. Commissioning is intended to ensure the quality and functionality of installed building systems and assemblies, optimize building system performance, ensure that owner and occupant requirements are met, and aid in the orderly transfer of systems to the university.

B. Commissioning is required on all projects. Utilization of outside resources will be decided on a project-by-project basis with approval of the university Facilities Operations through the University Project Manager. If no outside resources are utilized, then the engineer will complete the commissioning of the project.

C. Systems to be commissioned should include LEED Energy and Atmosphere minimum of fundamental commissioning prerequisites and should consider LEED Enhanced Commissioning work with the University Project Manager and LEED rating for new building, addition or major renovation.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Commissioning Authority shall:
   1. Coordinate and direct each step of the commissioning process, and recommend acceptance or non-acceptance to the university’s representative.
   2. Assist in clearly identifying problems encountered in testing the functional performance of the mechanical system and cooperatively assisting in the development of the solutions to those problems. These potential problems may involve mechanical design, mechanical installation, mechanical equipment, controls devices, controls installation, controls software, etc.
   3. Coordinate directly with each sub contractor with respect to their responsibility and contractual obligations.
   4. Obtain, assemble and submit commissioning documentation.
   5. Attend periodic on-site commissioning activities.
   6. Develop the commissioning plan and schedule.
   7. Develop the commissioning checklists and functional performance test plans. If there is a conflict between the requirements of the engineer and those of the Commissioning Authority, and the conflict cannot be resolved, the requirements of the Engineer shall have precedence.
   8. Coordinate the installation verification inspections.
   9. Review the control documentation and interface with other systems.
   10. Review the operation and maintenance information and as-built drawings provided by the various sub-contractors and vendors.
   11. Note any inconsistencies or deficiencies in the system.
   12. Enforce system compliance and recommend modifications to the system design that will correct or enhance the system performance.
   13. Coordinate the university’s representative for witnessing of the tests.
   14. Be present during start-up activities to assist and witness the execution of start-up checks and procedures.
   15. Monitor the performance of the Test, Adjust and Balance contractor.
   16. Review the accuracy and calibration of any instrumentation utilized for the functional performance testing and point to point testing.
   17. Direct the functional performance testing.
   18. Track commissioning deficiencies until correction.
   19. Prepare and submit the commissioning reports.
   20. Provide an 8 hour training class for up to six maintenance personnel.
   21. The Commissioning Authority shall include in the commissioning bid.
a. All required costs to identify the design and construction problems as they relate to the mechanical system functional performance and acceptance.
b. Assistance in the process of proposing solutions to mechanical system functional performance and acceptance problems.
c. Assistance in implementing the solution for a mechanical system functional performance and acceptance problem.

22. In the event that any one of the contractors or engineers are unwilling or unable to participate in the commissioning process and/or the resolution of problems identified in the commissioning process, that portion of the commissioning process shall be discontinued until such time that contractor/designer participation and problem resolution is resumed. The Commissioning Authority shall notify the university’s representative in writing of:
   a. The portion of the commissioning process in question.
   b. The problem being encountered with the system.
   c. The problem being encountered with the contractor/designer.
   d. The approximate costs encountered in attempting to get cooperation and projected costs in completing that portion of the commissioning process.

B. Smoke Management System Commissioning Authority:
   1. Inspect the following:
      a. Automatic dampers
      b. Fans
      c. Controls diagrams
      d. Marking & identification
   2. Verify the following:
      a. Vestibules
      b. Fans
      c. Detection devices
      d. Dampers
      e. Inlets and Outlets
      f. Smoke barriers
      g. Standby power
      h. Control action & Priorities
      i. Controls
      j. Response time
   3. Reports: Provide the following reports and forms:
      a. Verification plan
      b. Testing & Validation Forms
      c. Daily Log & Reports Forms
      d. Non-Compliance Forms

C. Design Engineer:
   1. Provide the Basis of Design Document (BoD) for individual systems and for overall building systems integration to meet the OPR. The Basis of Design Document shall use narrative descriptions, lists, schematics or other means necessary to clarify the design team’s approach to:
      a. Building energy conservation
      b. Achieving target sustainability ratings
      c. Optimization of system and equipment efficiency at partial loads
      d. Ventilation requirements
      e. Basis of selection for primary heat distribution/removal methods
      f. Building pressure control
      g. Standards and guidelines compliance
      h. Redundancy considerations
      i. Product selection
      And shall specify:
      j. Specific indoor/outdoor design conditions
      k. Key heat load calculation inputs
I. Equipment full load operating requirements
   m. Other criteria relevant to OPR requirements

2. The design engineer shall be responsible for the observations and checklists for the Installation Verification as defined in Part 3 of this Section.

3. Additional calculation and investigation of design adjustments needs by the engineers as defined by the Commissioning Authority.

4. Participate in the resolution of potential design concerns as discovered during the commissioning process.

D. Contractor:
   1. The contractor shall be responsible for the Pre-functional Testing, a start-up procedure performed prior to balancing as defined in Part 3 of this Section.
   2. The contractor shall be responsible for providing any technical personnel required for physical operation, testing and simulation of control sequences for each piece of controlled equipment as required by the Commissioning Authority during the Functional Performance Testing. This shall include chiller service personnel, boiler service personnel, the temperature control engineering and technical start-up crew, mechanical contracting service personnel for miscellaneous equipment, balancing contractor personnel, fire alarm contractor personnel, lighting contractor personnel, security system contractor personnel, and electrical contractor personnel. To the extent possible, these personnel will be scheduled.
   3. Additional calibration and adjustment of the mechanical equipment included in each mechanical system for proper operation under actual operation as defined by the Commissioning Authority.
   4. Additional testing, calibration, adjustments, tuning, and minor adjustments to the temperature controls system sequences for proper operation under actual operations defined by the Commissioning Authority.
   5. Additional testing, calibration and adjustment of the mechanical water and airflow of each mechanical system for proper operation under actual operation as defined by the Commissioning Authority.

E. The University shall:
   1. Develop the Owner’s Project Requirements (OPR) document in the pre-design phase with the assistance of the Commissioning Authority, and input from the design team, the end-user, and the O&M representative(s). Input shall be obtained using accepted methods such as questionnaires, surveys, workshops, etc. The OPR shall serve as the basis for the Basis of Design Document developed by the design team. The sections of the OPR pertaining to mechanical systems should detail:
      a. Minimum and maximum interior temperature requirements by space or room number.
      b. Interior air quality and humidity requirements by space type.
      c. Specific building or room pressurization requirements
      d. Projected occupancy levels and usage schedules
      e. Control system preferences or exclusions
      f. HVAC systems and equipment preferences or exclusions
      g. Specific standards compliance requirements (ie. ASHRAE, JCAHO, NFPA, etc.)
      h. Mechanical system requirements with respect to performance, compatibility, interoperability, redundancy, flexibility, or expandability
   2. Appoint and schedule the university’s representatives to participate in commissioning process.
   3. Advise Commissioning Authority regarding any changes in the Owner’s Project Requirements (OPR), such as building occupancy, usage, or functional requirements.

1.3 DEFINITIONS

A. Definition of Terms:
   1. OPR (Owner’s Project Requirements): a document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project oals, verifiable and quantitative performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This document is used as a basis for project design, commissioning...
activities, and acceptance criteria. The OPR should be a living, up-to-date document that reflects any changes made or approved by the owner throughout the design and construction phases.

2. Basis of Design (BoD) Document: A document developed by the architect/engineer in the design phase based on the Owner’s Project Requirements (OPR). The BoD describes the technical approach planned for the project as well as the design parameters to be used. The BoD translates OPR requirements into specific building components, systems, and control strategies and explains the justification for their selection. This document allows for necessary changes or modifications to take place in the design phase, and establishes requirements for the testing phase of project commissioning.

3. Installation Verification: This initial portion of the commissioning process includes observations and punch-list recorded and performed by the Engineer to ensure that all equipment is installed in accordance with the specifications and drawings. The Commissioning Authority shall oversee this process.

4. Pre-functional Testing: This portion of the commissioning process involves primarily the test and balance and startup personnel to ensure that individual pieces of equipment are capable of performing in accordance with the specifications, drawings, and manufacturer’s requirements. This is documented with a pre-functional checklist provided and completed by the contractor. The Commissioning Authority shall oversee this testing.

5. Functional Performance testing: This portion of the commissioning process involves dynamic tests that ensure all mechanical systems function in accordance with design intent as defined in the BoD. The tests are dynamic and on-line and test the systems through all possible modes of operation.

6. Calibration: To check or adjust the graduation of a quantitative measuring instrument against a known standard.

7. Adjustment: To change the speed, flow, position, signal, or level of any piece of mechanical equipment.

8. Turning: To adjust for maximum performance.

9. Minor Adjustment: To add, subtract, or change various parameters included on the operation of logic of a mechanical system or systems in order to improve or optimize operation performance. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major adjustment.

10. Major Adjustment: To fully change the specified operation logic of a mechanical system or systems. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major.

11. System Component or System Element: A single piece of mechanical equipment such as a pump, fan, chiller, boiler, coil, etc. that when combined together through piping or ductwork will comprise a “System”.

12. System: A combination of system components that allow the manufacturer or distribution of conditioned air or water from one location to another.

13. The commissioning process is a joint team effort to ensure that all mechanical equipment, controls, and systems function together properly to meet the design intent of the Engineer and to document system performance parameters for fine-tuning of control sequences and operation procedures.

14. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, training and performance testing. Testing and balancing, controls and training are addressed in other sections of the Specifications.

15. The commissioning described herein, in not intended to supersede or replace the normal system startup by the contracting team, observations by the design team or balancing by the test and balance contractor.

16. Commissioning Process: In as much as possible, the commissioning process shall occur during the construction of the project for all portions of the mechanical systems that are scheduled to be complete at the opening day. This is intended to:
   a. Reduce as much as possible any duplication of work or testing for the contractor.
   b. Identify and solve any potential mechanical system design or construction problems as they relate to functional performance, prior to opening day.
17. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems, and sub-systems. Evaluate the following equipment and systems:
   a. Hydronic distribution systems.
   b. Air handling and air distribution systems.
   c. Domestic hot water systems.
   d. Variable frequency drives.
   e. Fire protection and suppression systems.
   f. Exterior switches and transformers.
   g. Electrical unit substations, switch gear, distribution transformers, distribution panelboards, and branch panel boards.
   h. Lighting systems.
   i. Motor control centers.
   j. Stand-by power systems.
   k. Building automation systems, hardware, software, and documentation.
   l. UPS systems.
   m. Glazing.
   n. Insulation.
   o. Indoor air quality.
   p. Building and special room pressurization.
   q. Computer room air conditioning systems.
   r. Fume hoods and special exhaust systems.
   s. Security systems.
   t. Fire alarm systems.
   u. Lighting Protection systems.
   v. Energy metering:
      1) Steam
      2) Chilled water
      3) Electric
   y. Building Envelope

B. Commissioning Team:
1. The commissioning team shall be made up of the:
   a. Commissioning Authority
   b. Representative of the University
   c. Design Engineer
   d. Design Architect
   e. Construction Trades (specialty contractors)
2. The trades represented on the commissioning team will include:
   a. General Contractor
   b. Mechanical Contractor
   c. Electrical Contractor
   d. Building Automation System Contractor
   e. Fire Alarm System Contractor
   f. Test, Adjust and Balancing
3. The lead tradesman for each trade who will actually perform or supervise the commissioning work is to be designated as the representative to the commissioning team.
4. Responsibility for various steps of the commissioning process will be divided among the members of the commissioning team, as described in this section.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
A. Commissioning Process:

1. Meetings:
   a. Scope Meeting: Early in the construction process, a commissioning scope meeting involving all members of the commissioning team shall be held at a time and place designated by the University Project Manager. The purpose of the meeting will be to familiarize all parties with the requirements of the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
   b. Progress Meetings: During the course of the project, the Commissioning Authority shall conduct monthly commissioning meetings during the initial 75% of the project. During the final 25% of the project construction, the Commissioning Authority shall conduct weekly meetings.

2. Reports:
   a. General:
      1) The Commissioning Authority shall record and maintain detailed testing data. The data record shall be comprehensive and concise.
      2) All data must be recorded as soon as possible during the course of testing.
      3) All documentation shall have the date, time, and names of persons participating in the inspection and testing.
      4) All test instruments shall be documented for valid calibration.
      5) The engineer and Commissioning Authority must approve the recording work sheets, inspection checklists, and performance testing plans. Approval must occur prior to the start of Functional Performance Testing.
   b. Daily Commissioning Report Logs:
      1) The Commissioning Authority shall provide daily report logs to be included in the final report.
      2) The daily logs shall record the Commissioning Authority personnel and event summaries of meetings, conversations, tests, failures, solutions, procedures and successes.
   c. Functional Performance Test Plans, Tables and Checklist:
      1) The Commissioning Authority shall prepare detailed test plans with associated checklists to organize and document the Functional Performance Testing.
      2) A separate test plan is required for each device or control sequence.
      3) A separate checklist is required for each of the equipment/systems.
      4) Provide testing tables for large quantities of repetitive test events such as outside air volumes, VAV box close-offs, valves, etc.
   d. Final Report:
      1) The Commissioning Agent shall prepare and submit to the university’s representative a final report after completion of the commissioning.
      2) The report shall verify performance of HVAC equipment and systems.
      3) Documentation any field modifications to the testing process and why these modifications were made.
      4) The organizations of the final mechanical systems commissioning report shall be as follows:
         a) Executive Summary of each mechanical system and problems encountered and resolved.
         b) System Overview summarizing the system design.
         c) Commissioning Plan.
         d) Post Commissioned Controls Sequences and Points Lists.
         e) Prefunctional Testing Checklists.
         f) Functional Testing Procedures and Results.
         g) Smoke Control Testing Scenarios and Results.
         h) Appendix of letters, memo and notes occurring during the commissioning process.
      5) Final report in a PDF format with searchable text.

3.2 TESTING, CLEANING AND CERTIFICATION
A. General Requirements:

1. All systems and system components shall be tested in presence of Commissioning Authority (and the engineer, if desired by the engineer) to demonstrate compliance with specified requirements. To minimize the time of commissioning, contracting and engineering team members, testing shall be done in seasonal single blocks of time insofar as possible.
2. The contractor shall notify the Commissioning Authority fourteen (14) days prior to scheduled Functional Performance Tests, of the scheduled completion date of the Installation Verification and Pre-functional Testing.
3. All testing shall be conducted under specified design operating conditions as approved by Commissioning Authority and engineer.
4. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each subsystem, followed by entire system, followed by any inter-ties to other major systems.
5. All special testing materials and equipment shall be provided by contractor. This includes, but is not limited to balancing readout and adjustment tools.
6. Provide one copy of all test reports and records to Commissioning Authority.

B. Procedure and Test Documentation:

1. Within sixty (60) days prior to startup of the mechanical system, the Commissioning Authority shall prepare and submit to the university's representative and engineer for review, descriptions of the test procedures which the contractor will perform to demonstrate conformance of completed mechanical systems to the plans and specifications.
2. The decision of the Commissioning Authority and engineer upon acceptability of test procedures shall be final. In the event of an unresolved conflict between the Commissioning Authority and engineer, the engineer's decision shall have precedence. However, in no case shall such decision excuse the contractor from fulfilling the requirements of commissioning as described in this section.

C. Installation Verification Recommendations:

1. All systems and system components shall be checked and verified that they have been installed according to the drawings and specifications, and that all connections have been made correctly.
2. Each system of interactive system components shall be observed and verified that it is ready to function as specified.
3. Verification of complete and proper installation shall be completed prior to starting Component Performance Tests.
4. The Installation Verification shall be documented in a checklist format for each system/piece of equipment. Each checklist shall be dated and initialed by the engineer, mandatory.

D. Pre-functional Testing Requirements:

1. All system components shall be checked to verify that they have been installed properly and that all connections have been made correctly. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, calibration, control sequence or other conditions which may cause damage.
2. Verify that test, meter readings and specific electrical characteristics agree with those required by equipment or system manufacturer.
3. All discrete elements and sub-systems of system components shall be adjusted and shall be checked for proper operation. Verify wiring and support components for equipment are complete and tested.
4. The Pre-functional Tests shall be documented in a checklist format for each system and each piece of equipment. Each checklist shall be dated and initialed by the contractor, mandatory.

E. Functional Performance Testing Requirements:

1. The Functional Performance Testing portion of the commissioning process shall begin after the installation of the HVAC equipment and systems, along with related equipment, systems, structures, and areas are complete.
2. A Functional Performance Test shall be performed on each complete system. Each function shall be demonstrated to satisfaction of the Commissioning Authority on a paragraph-by-paragraph basis of the written test procedure, developed to demonstrate conformance to requirements of contract specifications and the Basis of Design Document.

3. Each functional Performance Test shall be witnessed and signed off by the Commissioning Authority and contractor (and the university's representative and engineer if requested) upon satisfactory completion.

4. The Functional Performance Testing Program shall be conducted in accordance with prior approved procedures and shall be documented as required hereinafter.

5. The Commissioning Authority shall notify the university's representative, the contracting team, the architect, and the engineer at least two weeks prior to date of scheduled Functional Performance Tests. Schedule each of the seasonal Functional Performance Test periods over a single block of days. The schedule seasonal Functional Performance Tests shall be based on the construction completion schedule. Further communication to the university representative, architect or engineer concerning the Functional Performance Testing schedule and changes to that schedule due to construction delays or coordination conflicts shall not be required unless the noted parties have expressed an interest in writing in attending the testing.

6. Mechanical System Tasks: Verify that the total HVAC mechanical system is performing to provide conditions all possible modes of operation as outlined in the Basis of Design Document (provided by the engineer). The Functional Performance Testing procedures shall statistically represent all operating characteristics of all mechanical equipment and systems, including:
   a. Air handling and ventilation systems operation including exhaust fans, heat pumps, and fancoils.
   b. Chilled water system operation including chillers, pumps and controls.
   c. Condenser water system operation including cooling towers, pumps and controls.
   d. Heating water or steam system operation including boilers, pumps and controls.
   e. Ventilation systems operation including air handling systems, exhaust fans, supply fans, makeup air systems and controls.
   f. Terminal unit operation such as variable air boxes, fancoils, and heat pumps.
   g. Pressurization system operation.

7. Building Automation System Tasks: Verify that the total building automation system control system is performing to provide conditions through all possible modes of operation as outlined in the Basis of Design Document (provided by the engineer). The Functional Performance Testing procedures shall address all operating characteristics of a statistical representation of control system equipment, sequences, and instrumentation calibration. Include a point-by-point check to verify connectivity and control.

8. Test and Balance (TAB) Verification Tasks: Verify TAB readings for the approximate quantities of the following:
   a. 50% of Fan flows.
   b. 50% of Pump flows.
   c. 50% of Outside air volumes.
   d. 50% of Equipment pressure drops.
   e. 10% of the Supply (maximum and minimum primary air) return and exhaust diffusers, registers, and grilles.
   f. 10% of Hydronic flows.
   g. 10% of Balancing valve/damper settings.
   h. 10% of VAV box setups.
   i. 10% of Coil pressure drops.
   j. If more than one-fifth of these readings differ from the documented TAB reading by more than 15 percent, then the TAB for the failed system shall be repeated in entirety.

3.3 COMMISSIONING (DEMONSTRATION)

A. The Commissioning Authority shall conduct a customized 8 hour training class for the university's engineering personnel in problem solving techniques with respect to the commissioned installation. This Commissioning Authority training does not reduce or exclude the training specified in other specification.
sections, although portions of other specification sections, although portions of other specified training may be included as a part of the Commissioning Authority training. This problem solving class shall focus on the following:

1. Present the mechanical system design as a whole, integrated unit.
2. Point out the unique qualities of the installed mechanical system.
3. Provide insights into how to solve system-wide, multi-faceted problems.
4. Identify a variety of resources available to assist with problem solving.
5. The problem solving class is not intended to teach day to day maintenance of parts and/or systems, establish emergency procedures, or "quick fix" problem solving approaches.

END OF SECTION 23 08 00
SECTION 23 09 00 - INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. These standards are minimum university requirements only. They are designed to clarify the university needs. They are not intended as a substitute for design services. Consultant shall provide a complete design and specification for the Building Automation Systems (BAS). This section may be referenced or portions copied and inserted into the specifications to clarify the university requirements. However, the design and specifications are the responsibility of the consultant not the university.

B. The Building Automation System (BAS) shall be a complete and fully integrated, microprocessor based BAS for control of HVAC and Building Environmental Processes.

C. The BAS shall interface with the lighting control system to schedule the HVAC system occupancies.

D. The Building Automation System applies only to the University of Colorado Anschutz Medical Campus. Contact the University Project Manager for Building Automation information regarding the University of Colorado Denver applications.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. The engineer shall clearly specify responsibilities between the BAS contractor, the TAB contractor the terminal box manufacturer and all other sections to provide a complete system that is installed without overlap.

1.3 SUBMITTALS

A. General:
   1. All submittal items in this section are in addition to Division 1.
   2. Submittals shall be complete, with detailed information on all items provided.
   3. All submittal requirements specified shall be provide as a single bound package. Provide six (6) submittal copies or the amount specified in Division 1, whichever is greater.

B. Submit AutoCAD (or AutoCAD compatible through DXF conversion) generated schematic in hardcopy and electronic media for the entire control system, for review and approval before work shall begin. The hardcopy drawings shall be submitted on 8-1/2” x 11” or 11” x 17” sheet with drawings information sized such that all drawing information is legible. The submittal drawings shall include the following:
   1. Communications:
      a. Provide a one-line diagram depicting the system architecture complete with a communication riser and peripheral devices.
      b. Provide a tabular listing of locations of controlled equipment, communications and network wiring layout, and panel locations with unit communication address identifiers.
   2. Point-to-point wiring diagrams for each HVAC system accurately depicting:
      a. Complete termination and configuration of all wiring and pneumatics. (This includes termination points for wires that are terminated on equipment supplied by others.)
      b. all temperature controls located on a schematic diagram of the controlled HVAC system
      c. start-stop wiring for each piece of equipment
      d. equipment interlocks
      e. wiring terminal numbers
      f. any special connection information required for properly controlling the mechanical equipment.
   3. Panel interior and panel face layouts.
C. A bill of material reference list with drawing tag identifiers, application description, manufacturer, complete model number, and quantity.

D. Identify all deviations from this standard and project documents.

E. Provide written sequences of operation which shall define all modes control strategies.

F. The submittals shall include manufacturers catalog data describing each item of control equipment or component provided and installed for the project.

1.4 WARRANTY

A. The BAS shall be warranted to be free from defects in both material and workmanship for a period of one (1) year of normal use and service. This warranty shall become effective the date the university accepts the system. The warranty shall include 24 hour per day, 7 day per week emergency problem response and all standard service contract preventative maintenance items (i.e. sensor calibration, linkage adjustment, etc.). An emergency service number shall be provided to the university. Response shall be within four (4) hours to the phone call.

B. Provide factory trained technicians familiar with the installation for emergency warranty service.

C. Upgrades: Include all controller firmware and software updates for the installed system version at no additional cost to the university during the warranty period.

D. Tuning: Include seasonal fine-tuning of PID loop parameters and other control parameters to provide an optimized control system to the university.

1.5 QUALITY ASSURANCE

A. Installation:
   1. The control system shall be furnished, engineered, and installed by the BAS manufacturer’s local office.
   2. Certain wiring and pneumatic installation may be performed by the BAS installer/manufacturer’s approved subcontractor under the direct supervision of the BAS installer/manufacturer’s field management.

B. Control system components shall be new and in conformance with the following applicable standards for products specified.
   1. American Society for testing and materials, ASTM
   2. Institute of Electrical and Electronic Engineers, IEEE
   3. National Electrical Manufacturers Association, NEMA
   4. Underwriters Laboratory, UL 916
   5. Underwriters Laboratory, UL 855 (Smoke Control Only)
   6. FCC Regulation, Part 15, Section 156
   7. National Fire Protection Association, NFPA
   8. Applicable Building Codes

1.6 SYSTEM DESIGN REQUIREMENTS

A. Campus Building Automation System Design Intent.
   1. Provide a single vendor, stand-alone Building Automation System (BAS) within each new or retrofitted building. Integrate the stand alone systems via the campus BAS data network.
   2. Systems shall be designed to be BACnet compatible.
   3. System shall be designed as an effective easy to use tool to operate, control, monitor and alarm mechanical equipment.
4. The system shall include all DDC controllers, sensors, valves, actuators, dampers, transmission equipment, software, local workstations, local panels, installation, setup, engineering, supervision, acceptance testing, training, and warranty necessary for a complete operable system.

5. The BAS shall be a full control system designed to control terminal equipment as well as main systems.

6. Each building and or renovation project shall provide adequate devices for monitoring and operating the BAS.

7. Each building shall include one or more BAS workstations to, based on password, allow full access to system configuration and monitoring.

B. System Architecture:
   1. The BAS control system architecture shall be comprised of four levels of DDC controls devices.
      a. Level 1: The first level is the system instrumentation component devices that includes but is not limited to sensors, valves, actuators, switches, relays, and transducers.
      b. Level 2: The second level includes the terminal equipment DDC controllers with specific applications for control of terminal units such as VAV boxes, fan coils and unit heaters.
      c. Level 3: The third level is comprised of general application DDC controllers for control of large primary mechanical systems such as air handling systems, heating hot water systems and chilled water systems. This level also performs system networking functions.
      d. Level 4: The fourth level consists of a file server, workstations and other devices that provide access, programming and setup tools, database management and other functions.
      e. Provisions for expansion of all levels of the DDC system shall be provided with each project such that a need for future “gateway” or “repeater” expansion hardware and software is not required.

2. Alternates:
   a. Variations from this general outline should meet the following functionality and be approved by the university.
   b. Non-intelligent slave panels may be utilized only to expand the controller point capacity for control of a single HVAC system, or specified monitoring not requiring control logic.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved BAS Installers/Manufacturers:
   1. University of Colorado Anschutz Medical Campus: Siemens Building Technologies
   2. University of Colorado Denver: Contact the University Project Manager

2.2 SYSTEM AND CONTROLLERS

A. All systems shall be configured and designed to be stand-alone.

B. All outputs including all outputs attached to terminal equipment controllers and special applications shall be directly commandable by the system operator. Any application that has outputs that can not be commanded by the operator shall not be accepted.

2.3 Terminal Equipment Controllers

A. Terminal Equipment Controller Hardware
   1. General:
      a. Each terminal equipment controller shall be a stand-alone DDC controller designed specifically for terminal unit control such as VAV boxes, fan coil units, heat pump units or similar application.
      b. The controller shall execute local control sequences, independent of a network controller or workstation.
c. All controllers shall preserve setup and programming from a loss of power for a minimum of 7 days.

2. Programs:
   a. The control program shall reside in the terminal equipment controller.
   b. The default data base, i.e. setpoints and configuration information, shall be stored in EEPROM or other non-volatile memory.

3. Stand-Alone:
   a. Controllers that share processing with a “master controller” shall not be acceptable.
   b. After a power failure the terminal equipment controller must run the control application without having to contact another controller.

4. Communications:
   a. Communications to the general application controller shall maintain the specified network throughput speed specified in the network controller hardware section.

5. Isolation:
   a. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watts at 3 feet.

6. Connections:
   a. All electrical connections shall be made to a combination terminal strip and base assembly.
   b. To insure long term reliability, all electrical terminations shall be screw type.

B. Terminal Equipment Controller Software:
   1. Controllers shall be provided with the capabilities required by the application.
   2. Each input, output or calculation result shall accessible from the terminal equipment controller communication port, application controllers and workstations.
   3. Controllers that require an EPROM burn to make permanent changes to the software configuration shall not be acceptable.
   4. All outputs for all controlled devices shall be directly commandable from the general application or network controller and from any workstation.
   5. Global commanding of outputs and setpoints shall be available to command any number of similar terminal equipment controller outputs to the same position with a single command.
   6. Terminal device controllers that do not allow separate space heating and space cooling setpoints to be configured shall not be accepted. This includes setpoint dial applications.

2.4 GENERAL APPLICATION CONTROLLERS

A. Hardware
   1. General
      a. The controller shall support all of the standards for the front-end software such as trending, alarming, etc.
      b. The general application controllers shall be a local control loop microprocessor-based controllers installed at each mechanical system; (i.e., air handling units, heating plants, chiller plants, etc.).
      c. The controller provides uplink and downlink communications, polling and other supervisory functions for terminal equipment controllers.
      d. Mechanical systems in close proximity with a small number of physical inputs and outputs may be combined in controllers with modular input output layouts.
      e. The controller shall be a true no-host system that does not require a PC or “Host” computer to perform any control functions or communication.
      f. Each controller shall be addressable by a workstation or a portable service tool.
      g. Non-intelligent slave panels may be utilize only to expand the controller point capacity for control of a single HVAC system, or monitoring without control logic.
      h. Self Diagnostics: The controller shall contain in its program, a self-test procedure for checking communications and, verify the functionality of the CPU memory.
      i. All equipment located on the roof shall be provided with an extra data drop for laptop connection. Locate roof mounted equipment in conditioned enclosures.
2. Each controller shall be provided with the memory capacity to store 1000 data samples for each physical analog point and 100 data samples for each physical digital point attached to it (including all expansion boards) and 400 data samples for each terminal equipment controller attached. This shall be in addition to the memory needed for all other functions of the panel.

3. Power Loss/Restart: The controller shall be tolerant of power failures. The memory shall be nonvolatile or unit shall hold memory for a minimum of four hours.
   a. Automatically and without operator intervention, the controller shall execute these restart procedures:
      1) Come on line
      2) Update all monitored functions
      3) Implement special building start-ups strategies as required
      4) Resume operation based on current time and status
   b. Controllers with batteries shall provide an alarmable point to the front end workstations when the batteries need to be replaced.

4. Network:
   a. Each general application controller shall connect to the campus Ethernet system.
   b. Multiple system workstation operators shall be able to access the controller simultaneously. Systems which do not provide multi-tasking, multi-user operating systems shall not be acceptable.
   c. Communication speed of each network shall have a maximum 10 second end-to-end throughput from a Level 1 device input to a Level 1 device output, anywhere in the system. Provide a system configuration that will maintain this minimum throughput speed during trend collection, recovery from power outages, and monitoring of multiple mechanical systems. Strategies to limit traffic shall not interfere with control or system monitoring.
   d. Uploading trends shall not interfere with control or monitoring operations

5. Isolation
   a. Control, communication and power circuits for each controller shall be individually electrically isolated to protect against transients, spikes, and power surges.
   b. The ports shall be optically and/or electrically isolated from each other, the controller circuit board and from power wiring.
   c. The controller shall be able to operate at 90% to 110% of nominal voltage rating.
   d. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watts at 3 feet.

6. Servicing:
   a. For ease of servicing, each controller shall consist of a removable plug-in circuit board.
   b. Products which require disconnection of wiring from the general application controller logic card before removal shall supply and install a quick disconnect type interconnection.
   c. If an air handler is located on the roof, locate equipment in conditioned enclosure of air handler.

7. Input/Output Modules:
   a. Analog inputs shall accept industry standard analog signals such as 4-20 mA, 0-5 VDC, and 0-10 VDC.
   b. Digital inputs shall accept binary contact closures.
   c. Digital outputs may be form C, latched or momentary contact type as required by the application.
      1) Digital output pairs controlling a tri-state motor/transducer or pulse width modulation shall not be utilized by general application controllers.
      2) Provide all digital outputs with hand/off/auto switches and LED status indication.
   d. Analog outputs shall have a 1% resolution over total output span of 0 to 100%.
      1) Provide all analog outputs with manual override switches and pot adjustments.
   e. Provide each control panel with a minimum 10% spare of each input and output type.

B. General Application Controller Software:
   1. Provide complete controller software to execute all mechanical system local loop controls functions.
2. Controllers that require an EPROM burn to make permanent changes to the software configuration shall not be acceptable.
3. Each input, output, or calculation result shall be capable of being assigned to the network controller for system networking.
4. Each controller shall be fully programmable both from a portable service tool at the controller and through the network communication system from the front-end workstation. Programs shall be able to be changed online without effecting other programs or point monitoring.

2.5 FRONT-END SOFTWARE

A. BAS Seat License
   1. Licenses shall be by concurrent user. Software shall be able to be installed on as many computers as necessary without additional licenses.
   2. Each building shall provide a minimum of one seat license.
   3. Additional licenses required are one seat license per 200,000 sq. ft. of lab or animal space and one seat license for every 400,000 sq. ft. of office and education space. No individual building shall be required to provide more than two seat licenses.

B. Software shall be a complete package including report management, alarm management, sequence programming language, live and historical data plotting capability, complete graphics with a library of HVAC symbols, program files for mechanical equipment and animation capabilities.

C. Software shall allow operator configurable reports that list in columns points chosen by the operator and attributes chosen by the operator.

D. Amount of trend data stored on the file server shall be limited only by the file server disk size and the discretion of the system administrator. Uploading data shall not effect the operation of the system.

E. Trend data shall be stored in an ASCI file for retrieval by standard “off-the-shelf” software programs.

2.6 WORKSTATION

A. Provide a minimum of one desktop workstation per building.
   1. Newest version of Windows approved by the university ITS department
   2. Processor speed, memory, should meet specifications necessary to run front-end BAS software without delays
   3. Minimum RAM: one Gigabyte
   4. CD reader/writer: DVD ROM/CD-RW
   5. Ports: USB
   6. Monitor: Minimum 17” flat panel LCD
   7. Network: Provide an ethernet PC Card compatible with the campus BAS network.
   8. Printer: Color Inkjet

B. The server-client workstations shall communicate via a campus-wide ethernet.

C. Perform all administrative tasks including but not limited to control program editing, graphics setup, alarm management, trend management, point setup, point commanding, report management and system setup.

2.7 PORTABLE OPERATION WORKSTATION HARDWARE:

A. Provide one (1) portable operator workstation which shall run the workstation software and includes the following minimum hardware configuration:
   1. Newest version of windows approved by the university ITS department
2. Processor speed, memory, should meet specifications necessary to run front-end BAS software without delays
3. CD reader/writer
4. Ports: Serial and USB
5. Monitor: Minimum 13” active matrix color LCD, Resolution sufficient to run BAS graphics without scrolling.
6. Power: Battery Life – 6 hours minimum. Provide Lithium-Ion type. Include (2) AC adaptors and (2) batteries.
7. Network: Provide an ethernet PC Card compatible with the campus BAS network.
8. Weight: 7.0 lbs. Maximum

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Provide a project manager who shall, as part of his duties, be responsible for the following
   1. Coordination between the Contractor and all other trades, the university, local authorities, and the design team.
   2. Scheduling of manpower, material delivery, equipment installation and checkout.
   3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD for project co-ordination and project record drawings.

B. Mount all panels at eye level in a workmanlike manor.

3.2 SYSTEM SETUP

A. Nomenclature: All point names shall comply with the existing point naming conventions. See Section 23 05 53 and the standard points list.

B. Point Setup
   1. See Section 23 09 32 for a list of required points.
   2. All physical analog outputs shall be setup to be commandable from the graphics with units of percent open to the energy source. This means mixed air dampers will be in percent open to outside air. The value of the physical units of the output shall also be available as live data.
   3. Points shall be setup so they read on reports and graphics with standard engineering units and without decimal places that exceed point updating or sensor accuracy.
   4. A graphic link will be installed for all points that are alarmed to allow drag and drop of alarms from the alarm status application to the appropriate graphic panel.

C. Trends
   1. All general application controller physical points, setpoints, and points on graphics shall be trended.
   2. All trends shall be scheduled for data transfer from the field panels to the database without data loss and without interfering with system operation.
   3. For archiving purposes, trends shall be setup to automatically transfer from the system database to files that can be easily used by standard spreadsheets.
   4. Analog points should have an interval trend of 15 minutes, 200 samples at the panel, and 45 days in the database.
      a. A change of value style of trend will be setup to record significant changes between the fifteen minute intervals.
   5. Digital points shall have change of value trends with a minimum of 50 changes from on to off or off to on stored in the panel, and 500 at the database or as needed for 45 days of data. Additionally, interval trend of 15 minutes, 200 samples at the panel, and 45 days at the database.

D. Locations
1. The room number for the mechanical system needs to be on the graphic. Where points on the graphic are not in the same room as the system, the location shall be in the point setup that can not be accidently deleted during manual manipulation of the point or on the graphic.

E. Graphics
1. The graphics should include all devices used by the control system and all controlled equipment.
2. The university must approve all graphic panels before they are copied.
3. All physical IO shall be on a graphic that enlightens the user to its function. All systems shall have graphics that convey accurate and complete schematic information about the equipment.
4. Graphics shall be clear and readable. Misleading details like construction room numbers and fonts that are too small to read shall not be used.
5. Use typical graphic developed by the university when available otherwise match existing style.
6. Each building will have a Building Chart that lists major AHU and building system parameters. It should be linked to each system graphic and the main graphic.
7. AHU graphics must contain utility and general information on the graphic. An air handler graphic shall have outside air and the properties of any chilled water, heating water, or steam supplied to the air handler.
8. The graphics shall either have links to all relevant graphics or be setup such that the operator will be able to navigate from the terminal box graphic to the relevant air handler graphic and back in less than three double clicks. The same shall be true between the terminal graphic and the related floor plan.
9. Each system graphic shall have a link to the sequence and a link to a maintenance log file.
10. Equipment references on the graphics will be compatible with the campus database naming conventions.
11. Controllers and miscellaneous alarm points will be located on the floor plan graphic.
12. Terminal equipment controller graphics shall be schematically correct, clear to read and have points arranged in a logical pattern to help viewer find information.
   a. All terminal box controllers, fan coils, unit heaters, exhaust boxes, etc. shall be located on a floor plan with a link to the relevant graphic.
   b. Terminal device graphics must contain utility and general information on the graphic. This would include supply air temperature, static pressure, heating water supply temperature or chilled water supply temperature as applicable.
   c. Terminal device graphics shall distinguish graphically between the type of equipment controlled such as VAV boxes, fan coils, hoods, general exhaust boxes etc.
   d. Points on the graphics that indicate position of terminal equipment controller outputs will read in percent open to energy source. All points necessary to command the outputs will be included on the graphics.
   e. Graphics shall be application specific with information on the discharge air temperature and pressure information specific to the air handler serving the terminal equipment controller.
13. Room numbers shall be included on the floor plans and shall be the university room numbers not the construction room numbers.
14. The operator shall be able to print any graphic including the live data.
15. Locate BAS panels on floor graphics.
16. Provide a graphic that overlays the mechanical contract drawing over the floor level graphics. Coordinate with BAS through the University Project Manager.
17. Show the miscellaneous points on the floor overview graphic at the installed location.
18. All points shall drag and drop and open the graphic associated with the point.
19. The graphics file shall be named the same as the background Designer file.

F. Alarms
1. Point alarms should follow the Standard Points List.
2. All general application controller and network controller communication failures shall be annunciated at the applicable system workstations as an alarm.
3. Priority 3 alarms shall be setup for failed batteries at the field panels.
4. All specified I/O device alarms shall be annunciated at the system workstation with alarm messages that clearly identify the type of alarm, the point in alarm and the value of the point in alarm.

5. All alarms shall be assigned priority levels with different notification strategies attached to each level. These alarm levels shall conform to the standards points list (see Section 23 09 32). The system administrator shall have complete control over notification strategies and alarm levels.

6. Alarm priorities
   a. Priority 1: Life safety (oxygen alarms, fire alarm), alarm effects entire building operation or research, emergency showers, water detection, environmental chambers, and emergency chilled water system activation.
   b. Priority 2: Research area/building alarms
   c. Priority 3: Office and teaching/building area alarms
   d. Priority 4: General maintenance alarms, such filters that do not require an immediate response
   e. Priority 5: BAS alarms, error codes, field panel failure alarms, battery alarms, non building related alarms
   f. Priority 6: Customer equipment alarms

7. All alarms with high priority shall be annunciated on alphanumeric pagers.
   a. Pager messages shall be fully changeable by the system administrator. They shall clearly identify the type of alarm, the building, the point in alarm and the value of the point in alarm.
   b. Critical alarms shall be sent to the paging system within 10 seconds.
   c. All paging shall be enhanced to include a minimum time delay, unless it is a critical alarm.

8. The alarm logic shall include adjustable high and low alarm limits, mixed mode expressions, and equipment interlocks.

9. Unique high and low limits shall be supplied for each analog alarm point in the system.

10. The system shall be programmed to suppress alarm reporting on primary equipment that is in the inactive state.

11. All alarmed points where the location is not obvious must have the location of the point in the point informational text or graphics.

12. Nuisance alarm suppression
   a. Alarms shall have an adjustment delay for the alarm condition to clear before the alarm is sent to workstations or pagers. If the condition clears before the delay is over the alarm shall not be sent.
   b. When the alarm conditions clears there shall be an adjustable time delay before an alarm clear is sent. If the alarm condition clears before the delay is over then no alarm clear shall be sent and the point shall remain in alarm.
   c. Provide enhanced alarming for filters, temperatures, and pressures using enhanced alarming.

13. All alarmed points where the location is not obvious must have the location of the point in the point informational text or graphics.

14. Confirm paging of alarms with the university BAS staff.

G. Database:
   1. After all punch list items have been completed export all of the following items and turnover to UCD:
      a. All points for every panel, including Virtual Points
      b. All terminal device points
      c. All programs
      d. All panel database files

H. Reporting:
   1. Create the following reports:
      a. Trend Collection report
      b. Operator report
      c. Failed Point Report.
2. For archiving purposes, fifteen minute interval reports should be setup for each mechanical system. Once a month they should automatically export last month’s data to a csv file on the file server. File names will be organized logically and include the date and system.

I. Graphing
   1. Create the following graphs:
      a. Historical graph for the last 45 days of performance for each major mechanical system.
      b. Dynamic graph of performance for each major mechanical system.

3.3 COMMISSIONING

A. Engineer shall include a complete specification for testing all BAS components as part of Section 23 08 00. Final testing shall not begin until after system is connected to the campus system and accessible from existing workstations.

B. Project Record Documentation:
   1. At least 3 working days before final acceptance demonstration, the contractor shall submit project record drawings of the BAS for approval by the university. If more than three errors or omissions are found during the university review or during the acceptance procedure the acceptance procedure will be cancelled and rescheduled when accurate and complete drawings are received.
   2. Project Record Documents shall include all the information in the submittal drawings plus:
      a. All communication wiring shall have the exact route shown on a floor plan.
      b. Include the working construction drawings set from the installation sub-contractor.
      c. Exact locations of all devices including panels, communication devices, IO devices, etc. shall be shown. Construction room numbers if different from the university room numbers do not meet this requirement.
      d. All changes made during installation shall be shown.
      e. The electrical circuits used by the BAS should be clearly indicated as panel and circuit number.
      f. Unit communication address identifiers shall be shown.
      g. Conductor and pneumatic tubing identifier numbers.

3. After receiving final approval, supply six (or as specified on Division 1) complete project record drawing sets (maximum ANSI “D” size), together with an electronic copy to the university. The project is not considered complete until record documents have been received and certified complete and accurate by the university.

4. O&M manuals shall be provided that detail any maintenance required for any device in the system.

5. After all punch list, commissioning has been completed, and the before the university accepts the project
   a. Run reporting for any unresolved lines for all programming.
   b. Run reporting to find any unused points and delete them from the database.
   c. Run reporting to find any unused commissioning, trends, reports and unneeded graphics.
   d. Run reporting for any database errors in database using the system activity log.
   e. Run reporting a network performance diagnostic test and provide report to the university.

3.4 TRAINING

A. Contractor shall provide to the engineer and the university a training class outline prior to any schedule training.

B. The control contractor shall conduct on-site training courses for designated university personnel in the maintenance and operation of the control system.
   1. A minimum of one class shall be given upon system acceptance. Classes shall be no longer than four hours in duration and budgeted at 1 hour of training time per 4000 sq. ft. of controlled area in labs and 1 hour per 7500 sq. ft. in office space. A minimum of one four hour class shall be provided.
2. Before training begins the O&Ms shall be complete the project BAS shall be communicating to the campus BAS.

3. Training sessions shall be provided for the university’s personnel by factory trained personnel knowledgeable about all aspects of the installation.

4. Training outline shall be coordinated with University Engineering and shall include as a minimum.
   a. Instruction on specific systems and instructions for operating the installed system
   b. A tour of the installation to show the location of all system components
   c. A review of the project documentation.
   d. A review of the sequences of operation.
   e. A review of graphical commanding and alarming.
   f. A review of the troubleshooting procedures
   g. A review of terminal controller operations.
   h. A review of emergency operation due to utility loss (power, chilled water, steam), panel failures, and major mechanical or electrical systems.
   i. A review of the O&Ms and the working construction drawing set from the installation subcontractor.

5. Provide 8 hours total of seasonal loop tuning.

C. The BAS contractor will provide, at no cost to the university, standard training for the operations staff. Such training shall be adequate to fully enable the student to perform any required operating procedures in the BAS.

D. Forty hours of factory training shall be provided for any Lab building over 80,000 sq. ft. Eighty hours of factory training shall be provided for any lab building over 300,000 sq. ft.

3.5 DEMOLITION

A. Demolition of an existing control system will include removal of controls which do not remain as part of the BAS, all associated abandoned wiring and conduit, and all associated pneumatic tubing.

B. The University Project Manager will inform the BAS Contractor of any equipment which is to be moved that will remain the property of the university. All other equipment which is removed will be disposed of by the BAS Contractor.

C. Existing controls which are to be reused must each be tested and calibrated for proper operation

D. Existing controls which are specified to be reused and are found to be defective requiring replacement will be noted to the University Project Manager. If necessary a change order will be issued to the contractor for repair or replacement of the defective device.

END OF SECTION 23 09 00
SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. The devices listed in this section are control system field devices generally connected to the Building Automation System. These devices have been placed in a separate section for clarity. See Section 23 09 00 for system standard and for items not clarified in this section.

B. Include all required factory and field calibration of each instrumentation device to accurately measure and control the desired variable.

C. Steam and chilled water connections and parameters from the Central Utilities Plant (CUP) to the individual buildings are further defined in Part 3 of the Manual of Guidelines and Standards for Design and Construction Projects and in the university Metering Standard.

D. All wiring requirements in this section shall be considered in addition to the requirements in Division 26 not in place of Division 26.

PART 2 - PRODUCTS

2.1 GENERAL

A. All input and output devices will be of the type which are universally accepted in the industry, can easily be second sourced and are fully compatible with the BAS.

B. Required components:
1. All components shall be included to meet the intent of sections 23 09 00 and 23 09 93
2. Pilot positioners shall be included where necessary to assure smooth operation of all analog pneumatic outputs.

2.2 SYSTEM INPUTS OR MEASUREMENT DEVICES

A. General
1. All sensor and signal conditioning equipment will be of the type which are universally accepted in the industry, can easily be second sourced and are compatible with all of the manufacturer’s equipment.
2. See section 23 09 93 for required points.
3. Provide components that are fully compatible with the Building Automation System (BAS). Include all required factory and field calibration of each instrumentation device to accurately measure the desired variable.
4. All sensors to be installed in conditioned areas to prevent damage to the device. All devices to be installed in areas within the operating range of the device.

B. Temperature Transmitters:
1. General: Temperature sensor/transmitters shall have ranges appropriate for applications, input resolution of 0.2 Deg. F, accuracy of .4 degree F and stability of .3 degree F over the entire span. Pneumatic sensors are not allowed.
2. Space:
   a. Space sensors (non-flush mounted) shall be provided with a portable service tool jack. Set-point adjustment will only be required as needed by LEED or the specific sequence of operation.
b. Sensors (non-flush mounted) shall be capable of providing temporary zone or building controls override, as needed by LEED and the specific sequence of operation.
c. Occupancy adjustment will only be required as needed by LEED or the specific sequence of operation.

3. Duct Averaging:
   a. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary.
   b. If the cross section of the duct where the sensor is located is larger that 24 inches long by 24 inches wide, averaging sensors of adequate length shall be specified to assure accurate temperature. Provide averaging sensors in all mixed air applications.

4. Outside Air: Sunshields shall be provided for outside air sensors.

5. Liquids
   a. Temperature sensors for liquids and steam shall have wells of appropriate type for the application and separable from the sensing element. Strap on sensors will not be accepted.

C. Differential Pressure Transmitters – Air and Water:
   1. General: The differential pressure transmitters shall be temperature compensated.
   2. Performance:
      a. Sensing range shall be suitable for the application with accuracy of +/- 1% including hysteresis and non-linearity of range and repeatability of +/- 0.2% of range.
      b. The sensor element shall be capable of withstanding up to 800% of rated pressure without damage.
      c. The sensor range shall be selected such that the anticipated set-point is approximately mid-range. Range may be larger if necessary to keep all anticipated measurements within the range.
   3. Air Application:
      a. The sensor element shall be capable of withstanding at least 5 psi differential pressure.
      b. For applications referencing outdoor air, provide an outdoor static reference enclosure that eliminates wind effects.
      c. Provide a metal pitot tube for all duct static measurements.
      d. Provide a recessed housing with metal fittings designed for space static measurements.
      e. Provide bi-directional sensors for all air filter monitoring.
   4. Water Application:
      a. For all water measurements, provide an isolation valve manifold and a permanently installed local visual gauge.
      b. The sensor element shall be capable of withstanding a pressure of twice the full scale pressure.
      c. Sensors shall have a minimum range of 0 - 50 PSI and a minimum of 100 PSI line pressure.

D. Humidity Transmitters:
   1. General:
      a. Humidity sensing elements shall be of the solid-state type.
   2. Performance:
      a. The sensing element shall have a minimum range of 10% -99%, with an accuracy of +/- 2% of range.
      b. Provide lockable metal guards for all sensors located in public areas.

E. Air Velocity Sensors For VAV Box Control:
   1. General:
      a. The sensor shall sense a velocity range that is appropriate for each box.
      b. Repeatability including transmitter shall be +/- 5% of the CFM reading across the range of flow required by the application.
      c. The consultant shall determine if the airflow transmitter included in the controller will meet the above accuracy and specify an external transmitter where necessary.
   2. Performance:
a. Thermal anemometer sensors shall use constant temperature differential technology and operate from 30 F degree F to 120 F. degrees F
b. Differential pressure sensors shall provide periodic auto-calibrate to insure accurate velocity pressure measurement at low flows.

F. Refrigerant Gas Monitoring:
   1. General:
      a. Provide an alarm light, horn, local digital LED readout, and a 4-20mA analog output to the BAS.
   2. Performance: Provide a halogen refrigerant gas monitoring system for the chiller room that shall specifically sense the type of refrigeration utilized in the chillers.
      a. The sensing range shall be such that the alarm level is approximately mid range of the full sensing range, with accuracy of +/- 3% of full scale.
      b. Sample each point a minimum of once every minute.
   3. The alarm levels shall be as follows:
      a. 10ppm for HCFC-123.
      b. 100ppm for HFC-134A and R-22.

G. Flow Sensor – Air:
   1. General:
      a. The sensor shall utilize a multi-point airflow measuring array with a minimum of one sensing point for every two square feet of area (rounded down).
   2. The accuracy of the flow measurement shall be +/- 3% of full scale.
   3. Airflow measuring element accuracy shall be +/- 2% of the actual airflow span.
   4. Differential Pressure Sensor/Transducer Performance: Refer to Differential Pressure Transmitter specification above.
   5. Mount airflow probes on fan inlets with locknuts. When use of locknuts is not an option, the use of “lock-tight” is acceptable.
   6. BAS air flow sensors shall be scaled to report in KCFM.

H. Flow Sensor – Steam / Energy Meter:
   1. Vortex Type: Piping location for meter must meet the manufacturer’s recommendation for minimum specified length of straight pipe. Meter sizing must consider maximum peak steam load and minimum steam flow during low load conditions (125 psi saturated steam). Dual station metering arrangement may be required to capture both peak flows and low-load off-season flow. Meter data communication must be coordinated with Building Automation System (BAS) interface requirements provided by Siemens. Acceptable communication protocols are Modbus and BACnet.
   2. Meter must be in place and demonstrated to be operational to campus energy engineer prior to utility start-up.
      a. Temperature and pressure compensated vortex-shedding mass flow meter.
      b. Flanged, in-line body, flow element with electronic transmitter producing a linear flow signal.
      c. High precision (0.4% of full scale) pressure transducer.
      d. 20:1 turndown ratio or better, accuracy better than 1% of span.
      e. Integrate meter data registers via approved communication protocol into Siemens BAS panel. Steam flow, pressure, temperature, flow totalizer registers are to be integrated into BAS at a minimum. Coordinate meter minimum and maximum flow output values with campus energy engineer through the University Project Manager.
      f. Mass flow will be totalized by meter and be integrated into BAS.
      g. NEMA 4X enclosure.
      h. Alphanumeric LCD display with user selectable display options.
      i. Integral mass flow totalizer with reset possible only with security code or non-resettable.
      j. Remote display is required if meter cannot be reached without ladder. Display shall be installed at eye level while standing on floor.
      k. Mounting hardware.
I. Calibration certification.
3. Acceptable Manufacturers: Sierra Instruments 240S or 240i series, Spirex/Sarco VLM series
4. Alternate technology acceptable product is Micrometer V-Cone series with KEP-ES flow computer for more difficult locations to meet manufacturer’s installation requirements. This product will need UCD engineering services approval prior to use.

I. Flow Sensor –Chilled Water Meter:
1. Ultrasonic Type: Piping location for meter must meet the manufacturer’s recommendation for minimum specified length of straight pipe. The metering of the cooling energy (chilled water) is based on the total BTU (British Thermal Units) of energy delivered to the building converted to cooling Ton-hours. Determination of Ton-hours of energy requires a minimum of two temperature sensors (one on the supply line, one on the return line) and a flow meter, preferably on the supply line (building chilled water design conditions are CHWS=41 degree F and CHWR=56 degree F).

   Meter data communication must be coordinated with Building Automation System (BAS) interface requirements provided by Siemens. Acceptable communication protocols are Modbus and BACnet.

2. Meter must be in place and demonstrated to be operational to campus energy engineer prior to utility start-up.
   a. Dual channel transit time flow and energy meter. Utilize 2 meters for single channel meters.
      1) Channel 1 for primary chilled water.
      2) Channel 2 for secondary chilled water.
   b. High precision clamp-on flow transducers.
   c. Insertion (wetted) type RTDs w/ 4 wire output (balanced) individually accurate to within 0.1 degree F and provided as a matched pair.
   d. NEMA 4X enclosure.
   e. Alphanumeric LCD display with user selectable display options.
   f. Integrated energy (Ton-hour) totalizer with reset possible only with security code or non-resettable.
   g. Integrate meter data registers via approved communication protocol into Siemens BAS panel. Minimum required registers shall be water flow rate, supply and return temperatures, cooling tons, totalized ton-hours.
   h. Display shall be installed at eye level while standing on floor.
   i. Mounting hardware.
   j. RTD and flow transducer cables.
   k. Calibration certification.
   l. Acceptable Manufacturers: Siemens SITRANS FUE1010 series, Spirex/Sarco UTM10-E series, Sierra Instruments InnovaSonic 205i series

J. Carbon Dioxide Sensor:
2. Performance:
   a. The sensor shall have a range of 0-2000 ppm
   b. Accuracy +/- 50 ppm
   c. Repeatability +/- 10 ppm.
   d. Drift less than 20 ppm/yr
   e. Sensors shall be field calibrated for altitude.

K. Current Transducer:
1. General:
   a. Rated for 120% of maximum amperage of monitored system with 4-20 mA output.
   b. Provide matched removable clamp-on type current transformer.
2. Performance:
   a. Accuracy: +/- 0.5% of full scale
   b. Repeatability/Linearity: +/- 0.1% of full scale.
L. Level Transmitter:
1. Capacitance Type: PTFE coated 316 SS probe with ¾ inch NPT or 150 LB connection, 4-20mA output.
2. Displacement Type: C-Iron or steel case with 316 SS displacer, specific gravity adjustment, 4-20mA output.
3. Ultrasonic Type:
   a. Two-inch NPT connection, CPVC material, auto temperature compensation, NEMA-4X housing, 120 VAC power mA isolated output.
   b. Provide two adjustable relay contacts which may be set to alarm at particular level values, an electronic transmitter corresponding to 0-100% of level span, self-testing and calibrating and adjustable noise/echo filters.

M. Water meters:
1. Application: Domestic water, irrigation, evaporative cooling
2. Meters shall meet or exceed AWWA C700 and C710 Standards, utilize magnetic drive register, have excellent low flow measurement.
3. Water meters shall have a pulse output to the BAS.
4. Acceptable Manufacturers: Badger, Neptune, Sensus
5. Badger (preferred):
   a. Up to 2” Recordall disc series, over 2” Turbo series, all Badger meters require RTR pulse transmitter
6. Neptune:
   a. Up to 2” T-10, over 2” HP Turbine, all Neptune meters require TRICON/E3 pulse transmitter
7. Sensus:
   a. Up to 2” SR II, over 2” Turbo, all Sensus meters require Sensus Pulse transmitter

N. Electric Energy/Power Meter:

2.3 SYSTEM OUTPUTS OR CONTROL DEVICES

A. Electro-Pneumatic Transducers (I/P):
1. General: Shall accept industry standard electronic signals and provide standardized pneumatic outputs.
2. Performance:
   a. The accuracy of conversion shall be 4% of full scale, linearity +/- 1% of full range at ambient temperatures of 40 to 120F.

B. Control Relays:
1. Shall be UL listed plug-in type with dust cover and LED “energized” indicator or RIB with indicator.
2. Contact rating, configuration and coil voltage shall be suitable for the application.

C. Manual Control Switches:
1. Shall be UL listed for use in NEMA 1 enclosures with contact arrangement and rating suitable for the application.
2. Bat handle or knob actuator with nameplate clearly identifying function of each switch position.

D. Low Temperature Protection Thermostats:
1. General:
   a. Shall be the manual reset type.
   b. The element shall be properly supported to cover the entire downstream side of the heating coil with a minimum of three loops.
   c. Separate thermostats shall be provided for each 25 square feet of coil face area or fraction thereof.
d. Provide a single point for low temperature reset button when 8 or more low temperature detectors are installed.

2. Performance:
   a. The set point shall be adjustable with a minimum range of 34 F to 50 F.
   b. The thermostat shall operate in response to the coldest one foot length of the 20 sensing element regardless of the temperature at other parts of the element.

E. Differential Pressure Switches:
1. Pressure differential switches (air or water service) shall be UL listed, Snap-acting, pilot duty rated (125 VA minimum), NEMA enclosure appropriate for the application, with scale range such that an adjustable set point is approximately at the mid-point of the device span.
2. Provide metal pitot tubes for airside differential pressure switches measuring duct static.

F. High/Low Static Pressure Limit Switches:
1. Shall be UL listed line voltage snap-acting pilot duty rated (125 VA minimum), NEMA 1 enclosure.
2. Provide manual reset unless otherwise required by the application
3. Provide metal pitot tubes for airside differential pressure switches measuring duct static.

G. Current Sensing Switches:
1. Shall be UL listed for line voltage with SPDT snap-acting, pilot duty rated (125 VA minimum) with range such that the set-point is at approximately the mid-point of span of the device.
2. Provide a maximum switching differential of 0.5 amps.

H. Valve or Damper Limit (End) Switches:
1. Shall be UL listed line voltage SPDT snap-acting pilot duty rated (125 VA minimum) NEMA 1 enclosure, with roller type actuating arm suitable for damper position application.
2. Provide end open and closed status switches as a minimum on all motorized valves utilized for equipment isolation. Provide end switches on all isolation dampers.

I. Positive Positioners:
1. General: Shall be high capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.
2. Performance:
   a. The positioner shall reposition the actuator on an input (pilot) signal change or 1/8 PSI or less.
   b. The repeatability shall be +/- 2%.

J. Electro-Pneumatic (EP) Solenoid Air Valves:
1. Shall be UL listed, snap-acting, 3 way air valve with 3-port (common, N.O, & N.C.).
2. Provide bronze or plastic body with stainless steel trim. Minimum safe pressure shall be 30 PSIG at 130 F ambient and/or control air temperature.
3. Provide coil voltages as required up to 460 VAC. Provide an open type for panel mounting or enclosed type with a NEMA 1 housing for remote installation.

K. Control Valves – Globe:
1. General: All control valves, unless otherwise required by application, shall meet the following:
   a. All modulating valve/actuator combinations for water application shall have linear flow or equal percentage characteristics in relationship to valve actuator input.
   b. The minimum close-off rating of any-two valve/actuator combination shall be 110% of the total system (pump) head for water application or 50 psid, whichever is greater.
   c. Valves shall have valve position indication on the valve.
   d. Water valves utilized in modulating applications shall be sized for a 4 to 6 psi drop with a maximum of 7 psi and a minimum of 3 psi. Application with flows less than 2 gpm may utilize pressure drops less than 3 psi.
   e. The valves shall be rated to 240 deg. F and 125 psig, two-way or three-way as required.
2. **Valves ½” to 1”**:  
   a. The valve body shall be nickel plated brass or bronze and provided with sweat or screwed fittings as required.  
   b. Provide a screwed type with NPT fittings. Provide valves with equal percentage or linear flow characteristics.

3. **Valves 1” to 6”**:  
   a. The valve body shall be cast iron with a chrome nickel steel or stainless steel seat and inner valve material.  
   b. Valves 1” to 2” shall be screwed type with NPT fittings.  
   c. Valves 2-1/2” and larger shall be flanged.  
   d. Provide linear flow characteristics.

4. **Valves 6” and Greater**: Provide one of the following types:  
   a. Rotary globe valves equal to Masonelian Camflex II. Provide equal percentage or linear flow characteristics.  
   b. Linear globe valves equal to Fisher. Provide equal percentage or linear flow characteristics.  
   c. High performance butterfly valves/actuator combination that shall provide equal percentage flow characteristics at low flow. Provide Keystone K-Loc.

L. **Control Valves – Butterfly**:  
   1. **General**:  
      a. Butterfly valves shall not be utilized for any modulating applications with valve sizes of six inches and under.  
      b. Butterfly valves utilized for two-position control shall be line-sized.  
      c. The minimum close-off rating for any two-way valve/actuator combination shall be 110% of the total system (pump) head for water application or 50 psid, whichever is greater.  
      d. All valves shall have valve position indication on the valve.

   2. **Construction**:  
      a. Two-way and three-way butterfly valves shall have:  
         1) a cast iron valve body  
         2) aluminized bronze disc  
         3) stainless steel stem  
         4) disc seal suitable for bubble-tight shut off

M. **Control Valves – Ball**:  
   1. **General**:  
      a. Ball valves shall not be utilized for modulating control unless approved by the engineer prior to bid. Exception: Only characterized ball valves providing equal percentage flow characteristics will be considered for modulating control applications.  
      b. The minimum close-off rating for any two-way valves/actuator combination shall be 110% of the total system (pump) head for water applications or 50 psid, whichever is greater.  
      c. All valves shall have position indication on the valve.  
      d. The pressure drop calculations shall include the pressure drops of the fittings required to install a valves several sizes smaller than the pipe it is being installed in.

   2. **Ball Valves (2” or less)**:  
      a. Valves shall utilize bronze bodies with female NPT threads. Valve bodies may also be stainless steel, titanium or nickel with operating pressure up to 2000 psi.  
      b. Provide a blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating. Stem packing gland screw shall be adjustable for wear.  
      c. Standard chromium plated bronze ball or where specified, stainless steel ball and stem, shall be rated at a minimum of 600 psi water, cold, non-shock service, and 150 psi for saturated steam service. All valves shall be provided with reinforced Teflon seats.

   3. **Ball Valves (2-1/2” to 6”)**:  
      a. Valves shall have flanged carbon steel or stainless steel bodies rated at 150 psi working pressure.  
      b. Provide a blowout stem design and reinforced PTFE thrust seal washer.

c. Provide a stainless steel ball and stem and reinforced PTFE seats, packing and o-ring.

N. Control Valves – Low Pressure Steam:
   1. General:
      a. Low pressure steam valves shall be sized for a maximum 42% pressure drop of inlet pressure.
      b. The minimum close-off rating any two-way valve/actuator combination shall be inlet pressure for steam applications.
      c. All valves shall have valve position indication on the valve.
      d. All modulating valve/actuator combination for steam applications shall have equal percentage flow characteristic in relation to valve actuator signal input.
   2. Construction:
      a. The valves shall be two-way with a rating to 360 deg. F up to 230 psig.
      b. The valve body shall be cast iron with a chrome nickel steel or stainless steel seat and inner valve material.

O. Control Valves – Chilled water Infrastructure Connection
   1. General:
      a. The control valve must be a two-way valve design.
      b. The control valve must be of industrial quality.
      c. When combined with actuator, the assembly must deliver a minimum 100:1 turn-down ratio.
      d. The minimum close-off rating any two-way valve/actuator combination shall be inlet pressure of 100 psi (230° W.C.) differential.
      e. All valves shall be sized for 3-5 PSID pressure drop across the valve at full flow.
      f. All valves shall have valve position indication on the valve.
      g. All modulating valve/actuator combination for this application shall have equal percentage flow characteristic in relation to valve actuator signal input.
   2. Construction:
      a. The valves shall be two-way with a rating to 360 deg. F up to 230 psig.
      b. The valve body shall be cast iron with a chrome nickel steel or stainless steel seat and inner valve material.

P. Valve Actuators – Chilled water Infrastructure Connection
   1. General:
      a. Shall provide tight close-off at design system pressure and shall provide smooth modulation at design flow and pressure conditions.
      b. The control valve actuator must be of industrial quality.
      c. When combined with actuator, the assembly must deliver a minimum 100:1 turn-down ratio.
      d. The minimum close-off rating any two-way valve/actuator combination shall be inlet pressure of 100 psi (230° W.C.) differential.
      e. The valve actuators shall be electrically actuated with proportional modulation and must fail in place.
      f. All modulating valve/actuator combination shall have valve position indication on the actuator.
      g. All modulating valve/actuator combination for this application shall have equal percentage flow characteristic in relation to valve actuator signal input.
      h. Provide a hand wheel or manual position dial to allow manual positioning of valve.
      i. Provide actuators with internal heaters if installed outdoors.
      j. Provide end (limit) switches for open/closed position indication feedback.
      k. Provide a position indicator feedback signal. Signal shall supply a mA or VDC analog feedback signal. It shall have infinite resolution with a linearity error of less than +/- 1% of full span.
1. Upon loss of analog control signal, the actuator shall have the ability of to stay in place, drive fully open, drive fully closed or drive to a pre-determined position.

2. Construction:
   a. The actuator shall function normally at temperatures of 40 to 185 degrees F, 0-99% humidity, and withstand short temperature excursions 10% above the rated temperature with no permanent damage to the unit.
   b. The motor shall be a no burnout type, with no duty cycle limitations, capable of 60 starts and stops per minute for high-demand times such as start-up and process upsets.
   c. The actuator shall hold a minimum of 200% of the rated torque when the motor is de-energized

3. Acceptable Manufacturers: Beck, or approved equivalent.

Q. Control Dampers:
   1. Motorized dampers, unless otherwise required by the application, shall meet the following:
      a. Damper frames shall use 12 or 13 gauge galvanized steel channel or 1/8” extruded aluminum with reinforced corner bracing.
      b. The damper blades shall not exceed eight (6) inches in width or 48” in length.
      c. Damper bearings shall be oil-impregnated sintered bronze or bearing grade nylon. Bushings that turn in the bearing are to be oil impregnated sintered metal.
      d. All blade edges and top and bottom of the frame shall be provided with replaceable, butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel, synthetic elastomer, or combinations of both. The seals shall provide a maximum leakage rate of ½% of maximum flow or 10 CFM/SF leakage at 4” W.C. close-off pressure.
      e. The damper linkage shall be concealed and provide a linear flow or equal percentage characteristic as required.
      f. Airfoil type dampers shall be used for any modulating air volume applications, pressure control applications, or air velocities greater than 1500 FPM.
      g. Provide a minimum of one damper actuator per damper section.

   2. Blade Arrangement:
      a. Unless parallel blade dampers are necessary for mixing outdoor/return air streams, dampers other than fire dampers shall be opposed blade type.

R. Electronic Actuators:
   1. Value Actuators for Primary HVAC Equipment:
      a. Shall provide tight close-off at design system pressure and shall provide smooth modulation at design flow and pressure conditions.
      b. The valve actuators shall be electrically actuated with proportional modulation and spring return.
      c. Provide a hand wheel at the valve or manual position dial mounted in the BAS panel to allow manual positioning of valve.

   2. Valve Actuators for Butterfly Valves:
      a. Shall provide tight close-off at design system pressure and shall provide smooth modulation over the full range of expected flow and pressure conditions.
      b. Provide actuators with internal heaters if installed outdoors.
      c. Provide 2 sets of end switches, one set for limiting of the stroke, the other set for open/closed position indication feedback.
      d. Provide a hand wheel at the valve or manual position dial mounted in the BAS panel to allow manual positioning of valve.

   3. Valve Actuators for VAV Terminal Units:
      a. The valve actuator shall be electrically actuated with proportional or 3 point floating modulation.
      b. Thermally actuated valve actuators are not acceptable.

   4. Damper Actuators for Primary Equipment:
      a. Shall be selected per manufacturer’s recommendations to provide sufficient close-off force to effectively seal damper and to provide smooth modulating control over the full range of expected flow and pressure conditions.
b. Shall be proportional modulating or 2-position as required by the application and have a position indicator for external indication of damper position.

c. Provide modulating actuators with manual override release to manually position the actuator without disconnecting damper linkage.

d. Provide adjustable stops for both open and closed positions.

e. Provide spring return to the closed position on all dampers that open to the outdoors.

5. Damper Actuators for VAV Box Terminal Unit Control:
   a. Provide a rotary type capable of permanent stall operation without damage.
   b. Provide adjustable stop pins on the actuator for stroke limit.
   c. The actuator shall fit directly over the damper shaft.
   d. VAV terminals 3,000 CFM or greater must be provided with high torque actuator.

S. Pneumatic Actuators:
   1. General:
      a. Pneumatic actuators shall be piston-rolling diaphragm type with easily replaceable beaded, molded neoprene diaphragm.
      b. Actuator size and spring ranges selected shall be suitable for intended application.
      c. Provide a manual position dial mounted in the BAS panel to allow manual positioning of each actuator or group of actuators utilized for a modulating control application.
      d. All modulating valve applications shall be provided with spring return to the normal position.
      e. All damper applications with outdoor air openings shall be provided with spring return to the closed position.
      f. All actuator torque rating shall be 150% of the requirements of the application.
   2. Damper Actuators:
      a. Shall be selected per manufacturer’s recommendations to provide sufficient close-off force to effectively seal damper and to provide smooth modulating control under design flow and pressure conditions.
      b. The actuator body shall be cast aluminum.
   3. Valve Actuator:
      a. Shall provide tight close-off at design system pressure and shall provide smooth modulation over the full range of expected flow and pressure conditions.
      b. The actuator body shall be cast aluminum.
   4. Positive Positioners: Shall be provided on actuators for inlet vane control, modulating dampers, and modulating valves to provide smooth modulation or proper sequencing.

2.4 AUXILIARY EQUIPMENT

A. Building Automation System (BAS) Controls Transformers:
   1. Shall be UL listed Class 2 current limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

B. Pneumatic Indicating Gauges and Test Ports:
   1. Control signal indicating and test gauges shall be 1-1/2”, back-connected, 0 to 30 PSIG.
   2. Test ports shall be quick-disconnect type using needle probe or threaded pin valve type.
   3. Permanent indicating gauges shall be furnished for all pneumatic transducer and relay outputs used to position actuators or PE switches.
   4. Gauges shall be in local control panels when applicable.
   5. Test ports shall be provided for all EP, relay and signal conditioning inputs which do not directly signal actuators.
   6. One main (supply) air pressure gage shall be installed in each local control panel.

C. Enclosures:
   1. General:
      a. Mounting: All Controllers, Relays, Transducers, transmitters, relays, etc. shall be housed in a NEMA enclosure rated for the installed conditions.
b. Panels shall be NEMA type suitable for applications as required with hinged door and key-lock latch.

2. Terminations and Connections:
   a. Interconnections between internal and face-mounted devices pre-piped and wired with color-coded tubing/conductors shall be neatly installed in plastic tray and/or tie-wrapped.
   b. All wiring within the panel shall be run in wiring tray in accordance with NEMA and UL standards, and shall meet all local codes.
   c. Terminals for field connections shall be UL listed for 600V service, individually identified per control shop drawings, with adequate clearance for field wiring.
   d. Control air terminations for field connection shall be individually identified as per control shop drawings.

3. General Application Controller Panel Enclosures
   a. Provide a 120 VAC receptacle in each panel, and a fused on/off power switch for the panel power supply. Where ganged together panels within 8 feet of each other may be served by the same convenience 120 VAC receptacles.
   b. Provide a main air gauge for control power sources to each local panel containing pneumatic controls. Provide air gages for each pneumatic output. Indicator lights on BAS outputs similar to Siemens module PTM6.1 do not meet this standard.
   c. Provide a final as-built control drawing of panel and related devices, reduced, laminated, and mounted inside of the panel door.
   d. Use of existing control panels to house new controllers is discouraged. Use of existing control panels for junction panels is acceptable under the following conditions.
      1) All excess devices, wiring and tubing shall be removed.
      2) All remaining devices, wiring and tubing shall be tagged and neatly revised.

D. Wiring and Conduit:
   1. All wire will be copper and meet the minimum wire size for the application.
   2. Input wiring shall not be in the same conduit as power wiring. Communication wiring shall not be in the same conduit as power or output wiring.
   3. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
   4. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum ½ inch galvanized EMT. Compression fittings shall be used for interior locations and watertight compression fittings for exterior locations. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
   5. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuator controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
   6. Junction boxes shall be provided at all cable splices, equipment terminations, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with cover. Exterior and damp location J-boxes shall be cast alloy FS boxes with threaded hubs and gasket sealed covers.
   7. Wire inside walls should be in conduit, low voltage wire in ceilings should be ran in the information system cable tray and should enter room along with other low voltage wiring through a 2” conduit from the cable tray to a point of penetration in the adjacent room and run on J Hooks or bridle rings in the ceiling space of a room.
   8. Low Voltage/Wire and Cable: All LV/W&C shall be run in conduit in floors and walls spaces. In hallways LV/W&C shall be run in the common telecom and other low voltage system cable tray. LV/W&C must be run in a conduit sleeve, minimum 2” dia. with plastic bushings, from the point it leaves the cable tray to the interior side of a room. Once the LV/W&C enters the room it can be supported from bridle rings or j-hooks. Wiring shall comply with Section 28 31 00 and approved NEC.
   9. Low Voltage/Wire and Cable and Hallway Devices: LV/W&C running from the cable tray to devices in the hallway shall be protected by plenum rated flexible sleeving or flexible metal conduit. LV/W&C in sleeving or flexible metal conduit shall be supported per NEC and installed with UL approved connectors and plastic bushings on both ends.
10. **Low Voltage/Wire and Cable Insulation Sleeve Color:** BAS conductor insulation colors allowed are:
   a. Points Blue Jacket
   b. BLN Orange Jacket
   c. FLN Orange with blue stripe jacket
   d. Power Dark blue or black jacket

11. Where the space above a suspended ceiling is a supply or return air plenum, any wiring not run in conduit shall be plenum rated. **EXCEPTION:** Any wire run in suspended ceiling that is used to control outside air dampers, provide smoke control functions or to connect the system to the fire management system shall be in conduit.

**E. Pneumatic Tubing:**
1. Provide a complete air piping system for pneumatic actuator controls.
2. Control air piping shall be hard drawn type “L” copper tubing with wrought copper fittings and lead free joints.
3. Polyethylene tubing “FR” (flame retardant and self-extinguishing) can only be for terminal connections to devices with a maximum length of 18 inches and within control cabinets, enclosed raceways or conduits.
4. All pneumatic tubing shall be copper tubing or routed within a metallic conduit system.
5. Conceal piping except in:
   a. Mechanical rooms.
   b. Areas where other piping is exposed.
6. Secure exposed copper tubing at regular intervals and run parallel with the lines of the building.
7. Install only tool-made pipe bends.
8. Where exposed in mechanical rooms and occupied spaces, support non-metallic tubing in:
   a. Adequately-supported, rigid, metallic raceways (conduit).
   b. EMT pipe
   c. Install in a neat and workman-like manner.
10. All tubing penetrating a metal barrier (i.e. air handler casing or duct) shall be protected with bulkhead fittings.
11. Tie and support the tubing neatly.
12. Number-code or color-code tubing, except local individual room control tubing for future identification and servicing of control system.
13. Do not install pneumatic devices or tubing where there is danger of freezing.
14. Provide gauges on all branch lines from transducers. Locate in cabinet.
15. Provide gauges on all output transducers.

**PART 3 - EXECUTION**

**3.1 INSTALLATION, GENERAL**

A. Remote control devices not in local panels shall be accessible for adjustment and service-below 7’ above finished floor whenever possible.

B. All transducers, transmitters, relays, etc., shall be mounted in a panel with hinged doors in an orderly manner and shall be properly labeled with permanent labels to identify the parts of the system being served. All thermostats shall be labeled with device number and point address.

C. Component panels shall be mounted at eye level for accessibility and service, and located within 50 feet of the system served, unless otherwise shown on the plans.

**3.2 SYSTEM INPUTS OR MEASUREMENT DEVICES**
A. Temperature Sensors:
   1. Space: Mount room temperature sensors 60 inches above finished floor.
   2. Outside Air:
      a. The contractor is responsible for providing a sensor that accurately reflects outdoor air
         temperature throughout the year in any weather conditions.
      b. The outside air temperature sensor shall be located on a northern exposure away from any
         heat sinks or sources.
      c. Sunshields shall be provided such that the sensor is shaded for all possible solar angles.
   3. Duct Averaging
      a. The sensor shall be installed according to manufacturer’s recommendation and looped and
         fastened at a minimum of every 36 inches. Firmly supported ½’ EMT is acceptable.
      b. The sensor shall be thermally isolated from the unit.
   4. Water:
      a. Temperature sensors for liquids and steam shall be installed in wells of appropriate type for
         the application. Strap on sensors will not be accepted.
      b. Coordinate the locations of all thermo wells to provide for accurate and reliable
         temperature readings.
      c. Provide heat conductive compound between the well and sensor element.

B. Low Temperature Protection Thermostats:
   a. All low limit thermostats shall be firmly supported in the ductwork or air handling unit
      using ½” EMT or other auxiliary support.

C. Humidity Transmitters: Duct mounted sensors shall be mounted a minimum of 20 duct diameters
   downstream of any type of humidifiers or evaporative cooling equipment.

D. Differential Pressure Transmitters:
   1. Coordinate the locations of all water pressure differential transmitters such that the transmitter is
      located in the hydronically furthest lines. Confirm that there are no automatic modulating or two
      position valves between the transmitter taps and the pump.
   2. Locate the air pressure differential transmitter for VAV fan control approximately 2/3rd of the
      distance down the furthest duct. A location at or near the air handling system supply fan discharge
      is unacceptable.

E. Flow Meters
   1. All weld-o-lets for flow meters must be installed in a manner that no lip is in the pipe.

F. Airflow Stations
   1. The installation shall be a minimum of 10 duct diameters below and 5 duct diameters above any
      tees or elbows in the ductwork or in the inlet cone for each supply and return fan. If the fans are
      double wheel double inlet (DWDI) fans, provide a flow sensor at each fan inlet.

G. Air Velocity Sensors for Terminal Box Control
   1. The terminal box air flow measurement needs to be installed with the minimum duct diameters to
      assure accurate measurement of minimum ventilation air flow.

H. Differential pressure Switches
   1. All differential pressure switches shall be calibrated to specifications provided by the mechanical
      engineer.

3.3 AUXILIARY EQUIPMENT

A. Wiring Installation Methods:
   1. General:
a. At a minimum, install systems and materials in accordance with manufacturer’s instructions, rough in drawings and equipment details.
b. Install electrical components in compliance with requirements of applicable Sections of Division 26.
c. Install all control wiring 50 volts and above in conduit.

2. Installation:
a. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines, with adequate support and shall be supported from or anchored to structural members.
b. Conduit supported from or anchored to piping, duct supports, the ceiling suspension system, or other electrical conduits are not acceptable.
c. Wiring buried in slab on grade concrete or explosion proof areas shall be in rigid metal conduit.
d. Provide adequate strain relief for all field terminations.
e. Varistors shall be installed on the control side of all output relays and on both sides of the transformers.
f. All terminations shall be neat with no stray strands.
g. An additional number of spare wires shall be included in each run as determined by the university for future use.

B. Control Air Piping Installation Methods:
1. General:
a. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.

2. Installation:
a. Piping above suspended ceilings shall be supported from or anchored to structural members.
b. Tubing shall not be supported by or anchored to electrical conduits or the ceiling suspension system.
c. Sleeve through concrete surfaces in minimum one inch (25 mm) sleeves, extended 6 inches (150 mm) above floors and one inch (25 mm) below bottom surface of slabs.
d. Isolate air supply with wire-braid reinforced rubber hose or polyethylene tubing.
e. Purge tubing with dry, oil-free compressed air before connecting control instruments.
f. Lines buried in slab on grade concrete shall be in rigid metal conduit. Lines in concrete or masonry walls shall be in EMT.
g. All pneumatic piping that penetrates metal shall be protected with grommets from wear from the metal.

C. Identification:
1. General
a. Verify label nomenclature with the university before engraving or printing.
b. All control equipment shall be individually and clearly identified by control shop drawing designation:
c. Paper labels are not acceptable.

2. Control Panels
a. Provide engraved Bakelite or lithographed metal nameplates with panel number and system served
b. Utilize white ½ inch high letters on a black background.
c. Embossed labels are not acceptable

3. Component sub-panels – metal tags or laser printed, adhesive backed, metallized polyester film labels.
4. Control valves and damper actuators – brass tags or engraved Bakelite tags.
5. Other remote control devices – metal tags or laser printed, adhesive backed, metallized polyester film labels.
7. Label room temperature sensors with point name and address of the terminal controller served by the sensor.
8. For all control devices located above the ceiling attach an additional label to the ceiling “T” frame with pop rivets. Use engraved nameplates, 3”x1”, black lettering on white background.
9. Number-code conductors and pneumatic tubing appropriately for future identification and servicing of control system. Reflect this tagging or color coding system on the Project Record Documents

D. VFD interface wiring.
1. All safety circuit and BAS control wiring to VFDs shall be connected to a terminal strip in a NEMA enclosure external to the drive before entering the drive. This is to allow servicing these circuits without opening the drive.

END OF SECTION 23 09 13
SECTION 23 09 93 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. The Engineer shall submit to the university for review and comment a complete sequence of operations two weeks before final documents are sent out to bid.

1.2 SYSTEM DESIGN REQUIREMENTS

A. All sequences shall be written to maximize energy conservation
B. All units that can be placed on a schedule shall have complete schedule control including optimum start and an optimized unoccupied space heating and cooling.
C. Separate supply air temperature setpoints for heating components and cooling components in air handling unit shall be specified unless application makes impractical
D. Complete schedule control shall be included for terminal devices such as baseboard heating, VAV boxes that auditoriums, classrooms, conference rooms and other scheduled areas regardless of whether they are served by a dedicated air handler.
E. Separate room heating and room cooling setpoints shall be included for space comfort except where prohibited by space design parameters.
F. All conference rooms, all class rooms, and all other of 50 person occupancy or greater shall have demand controlled ventilation designed by the engineer using carbon dioxide sensing in the space. Areas served by economizer systems that are not practical for complete coverage with space CO2 sensors shall have CO2 sensors in the return duct. Air supply dampers shall close with unoccupied and room temperature set points have been met.
G. Sequences for the chilled water system shall conform to the university Metering Standard.
H. Typical VFD point set-up:
   1. The virtual L2SL point changes state based upon the programming and the LDO is set to the value of the L2SL in programming.
   2. Physical digital output point with VFD enable (LDO)
   3. RA-L26-P-003-RVD-LDO
   4. Physical digital input for alarming (LDI)
   5. RA-L26-P-003-RVD-LDI
   6. Virtual and physical point used for system alarming (L2SL)
   7. RA-L26-P-003-RVD-ENA
   8. LDO is virtual and LDI physical
I. Normal (Power Fail) positions for dampers and valves are as follows:
   1. Outside air damper: Closed (NC)
   2. Exhaust air damper: Closed (NC)
   3. Return air damper: Open (NO)
   4. Primary AHU HW or Steam Valves: Open (NO)
   5. Primary AHU CHW Valves: Closed (NC)
   6. Terminal Unit Reheat Valves: Closed (NC) or Fail to Last Position (FLP)
   7. Chiller – Chilled Water Isolation Valves: Fail to Last Position (FLP)
   8. Chiller – Condenser Water Isolation Valves: Fail to Last Position (FLP)
9. Cooling Tower Isolation Valves: Fail to Last Position (FLP)
10. Boiler Isolation Valves: Fail to Last Position (FLP)
11. Heating Water Mixing Valve: Fail to Heat
12. Steam Valves for Heat Exchangers: Closed (NC)
13. Heating coil valves for animal housing applications to fail closed. Verify with the University Project Manager.

1.3 STANDARD POINTS LIST

A. General

1. Simulated analog outputs such as tri-state digital output pairs or pulse width modulation shall not be allowed except in dedicated controllers.
2. Fan and pump status inputs shall be independent current switches, not contacts, on any VFD.
3. Alarm priorities are a starting point and can be adjusted by the university after project commissioning.
4. All VFDs shall have an RS485 communications port compatible with the BAS. Speed control, VFD speed, Fan start/stop, and VFD alarm points can be through this port.
5. Priorities 1 or 2 shall be set up to call the alpha numeric pagers.
6. This standard points list is a minimum only. The Engineer and BAS controls contractor are responsible for providing a complete BAS system.
7. VFDs to show actual speed and if in hand,
8. Fire alarm and trouble for each building.
10. High condensate tank level.
11. Fire pump and jockey pump status

B. Point Lists

<p>| Typical Physical Points - Mixed Air, VAV, Heating Water Preheat |
|-----------------------------------|----------------|----------------|
| SUBPOINT NAME | TYPE | DESCRIPTION |
| RAT | LAI | RETURN TEMP |
| RHR | LAI | RETURN HUMIDITY (RH MEASUREMENT WILL BE MADE USING SPACE RH LEVEL/S.) |
| LSPA | LDI | LOW STATIC PRESS |
| ALM | LDI | RETURN VFD ALARM |
| ENA | LDO/LDI | RETURN VFD ENA |
| HND | LDI | RETURN VFD HOA |
| HZ | LAI | RETURN VFD Hertz |
| LDI | LDI | RETURN VFD LDI |
| LDO | LDO | RETURN VFD LDO |
| SPD | LAO | RETURN VFD SPEED |
| CFM | LAI | RETURN CFM |
| ESP | LAI | RETURN STATIC |
| EAD | LAO | EXHAUST DAMPER |
| RAD | LAO | RETURN DAMPER |
| OAD | LAO | OUTSIDE DAMPER |
| OAD-CFM | LAI | OUTSIDE CFM |
| MOAD | LAO | MINIMUM DAMPER (IF REQUIRED AND CONTROL BY BAS) |
| MOAD-CFM | LAI | MINIMUM CFM (IF REQUIRED AND CONTROL BY BAS) |
| MAT | LAI | MIXED TEMP |
| PFLT | LAI | PRE-FILTER |
| FFLT | LAI | FINAL FILTER |
| FLT | LAI | FILTER (IF THERE IS ONLY ONE FILTER) |</p>
<table>
<thead>
<tr>
<th>HCV</th>
<th>LAO</th>
<th>HEATING VALVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCPM</td>
<td>LDO/LDI</td>
<td>HEATING PUMP</td>
</tr>
<tr>
<td>HCT</td>
<td>LAI</td>
<td>HEATING TEMP</td>
</tr>
<tr>
<td>ALM</td>
<td>LDI</td>
<td>SUPPLY VFD ALARM</td>
</tr>
<tr>
<td>ENA</td>
<td>LDO/LDI</td>
<td>SUPPLY VFD ENA</td>
</tr>
<tr>
<td>HND</td>
<td>LDI</td>
<td>SUPPLY VFD HOA</td>
</tr>
<tr>
<td>HZ</td>
<td>LAI</td>
<td>SUPPLY VFD Hertz</td>
</tr>
<tr>
<td>LDI</td>
<td>LDI</td>
<td>SUPPLY VFD LDI</td>
</tr>
<tr>
<td>LDO</td>
<td>LDO</td>
<td>SUPPLY VFD LDO</td>
</tr>
<tr>
<td>SPD</td>
<td>LAO</td>
<td>SUPPLY VFD SPEED</td>
</tr>
<tr>
<td>CFM</td>
<td>LAI</td>
<td>SUPPLY CFM</td>
</tr>
<tr>
<td>LTD</td>
<td>LDI</td>
<td>LOW TEMP DETECT</td>
</tr>
<tr>
<td>HSPA</td>
<td>LDI</td>
<td>LOW STATIC PRESS</td>
</tr>
<tr>
<td>CCV</td>
<td>LAO</td>
<td>COOLING VALVE</td>
</tr>
<tr>
<td>CCPM</td>
<td>LDO/LDI</td>
<td>COOLING PUMP (IF REQUIRED)</td>
</tr>
<tr>
<td>CCT</td>
<td>LAI</td>
<td>COOLING TEMP</td>
</tr>
<tr>
<td>EVPM</td>
<td>LDO/LDI</td>
<td>EVAP PUMP ENABLE</td>
</tr>
<tr>
<td>EVDV</td>
<td>LDO</td>
<td>FILL-DRAIN VALVE</td>
</tr>
<tr>
<td>EVCV</td>
<td>LDO</td>
<td>BLEED DOWN VALVE</td>
</tr>
<tr>
<td>EVBD</td>
<td>LAO</td>
<td>BYPASS DAMPER</td>
</tr>
<tr>
<td>EVC</td>
<td>LAI</td>
<td>EVAP CONDUCTIVITY</td>
</tr>
<tr>
<td>SAT</td>
<td>LAI</td>
<td>SUPPLY TEMP</td>
</tr>
<tr>
<td>SD</td>
<td>LDI</td>
<td>SMOKE DETECTOR</td>
</tr>
<tr>
<td>SSP</td>
<td>LAI</td>
<td>SUPPLY STATIC</td>
</tr>
<tr>
<td>BSP</td>
<td>LAI</td>
<td>BUILDING STATIC</td>
</tr>
</tbody>
</table>
### TYPICAL PHYSICAL POINTS – 100% OUTSIDE AIR, VAV, STEAM PREHEAT

<table>
<thead>
<tr>
<th>Subpoint Name Suffix</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IID</td>
<td>LDI</td>
<td>INTAKE DAMPER (DAMPER CONTROLLED BT VFD)</td>
</tr>
<tr>
<td>PFLT</td>
<td>LAI</td>
<td>PRE-FILTER</td>
</tr>
<tr>
<td>FLT</td>
<td>LAI</td>
<td>FINAL FILTER</td>
</tr>
<tr>
<td>HRV</td>
<td>LAO</td>
<td>HEAT RECOV VALVE (3-WAY)</td>
</tr>
<tr>
<td>HRT</td>
<td>LAI</td>
<td>HEAT RECOV TEMP</td>
</tr>
<tr>
<td>HCV</td>
<td>LAO</td>
<td>HEATING VALVE</td>
</tr>
<tr>
<td>FBD</td>
<td>LAO</td>
<td>BYPASS DAMPER</td>
</tr>
<tr>
<td>HCPM</td>
<td>LDO/LDI</td>
<td>HEATING PUMP</td>
</tr>
<tr>
<td>HCT</td>
<td>LAI</td>
<td>HEATING TEMP</td>
</tr>
<tr>
<td>LSPA</td>
<td>LDI</td>
<td>LOW STATIC PRESS</td>
</tr>
<tr>
<td>ALM</td>
<td>LDI</td>
<td>SUPPLY VFD ALARM</td>
</tr>
<tr>
<td>ENA</td>
<td>LDO/LDI</td>
<td>SUPPLY VFD ENA</td>
</tr>
<tr>
<td>HND</td>
<td>LDI</td>
<td>SUPPLY VFD HOA</td>
</tr>
<tr>
<td>HZ</td>
<td>LAI</td>
<td>SUPPLY VFD Hertz</td>
</tr>
<tr>
<td>LDI</td>
<td>LAI</td>
<td>SUPPLY VFD LDI</td>
</tr>
<tr>
<td>LDO</td>
<td>LDO</td>
<td>SUPPLY VFD LDO</td>
</tr>
<tr>
<td>SPD</td>
<td>LAO</td>
<td>SUPPLY VFD SPEED</td>
</tr>
<tr>
<td>CFM</td>
<td>LAI</td>
<td>SUPPLY CFM</td>
</tr>
<tr>
<td>LTD</td>
<td>LDI</td>
<td>LOW TEMP DETECT</td>
</tr>
<tr>
<td>HSPA</td>
<td>LDI</td>
<td>HIGH STATIC PRESS</td>
</tr>
<tr>
<td>CCV</td>
<td>LAO</td>
<td>COOLING VALVE</td>
</tr>
<tr>
<td>CCPM</td>
<td>LDO/LDI</td>
<td>COOLING PUMP (IF REQUIRED)</td>
</tr>
<tr>
<td>CCT</td>
<td>LAI</td>
<td>COOLING TEMP</td>
</tr>
<tr>
<td>EVPM</td>
<td>LDO/LDI</td>
<td>EVAP PUMP ENABLE</td>
</tr>
<tr>
<td>EVDV</td>
<td>LDO</td>
<td>FILL-DRAIN VALVE</td>
</tr>
<tr>
<td>EVCV</td>
<td>LDO</td>
<td>BLEED DOWN VALVE</td>
</tr>
<tr>
<td>EVBD</td>
<td>LAO</td>
<td>EVAP BYPASS DAMPER</td>
</tr>
<tr>
<td>EVC</td>
<td>LAI</td>
<td>EVAP CONDUCTIVITY</td>
</tr>
<tr>
<td>SAT</td>
<td>LAI</td>
<td>SUPPLY TEMP</td>
</tr>
<tr>
<td>SD</td>
<td>LDI</td>
<td>SMOKE DETECTOR</td>
</tr>
<tr>
<td>DID</td>
<td>LDI</td>
<td>DISCHARGE DAMPER (DAMPER CONTROLLED BT VFD)</td>
</tr>
<tr>
<td>SSP</td>
<td>LAI</td>
<td>SUPPLY STATIC</td>
</tr>
<tr>
<td>BSP</td>
<td>LAI</td>
<td>BUILDING STATIC</td>
</tr>
<tr>
<td>RHRM</td>
<td>LAI</td>
<td>RELATIVE HUMIDITY (RH MEASUREMENT WILL BE MADE USING SPACE RH LEVEL/S.)</td>
</tr>
</tbody>
</table>

### Typical Physical Points - Heating water system fed from the CUP

<table>
<thead>
<tr>
<th>Subpoint Name Suffix</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLW</td>
<td>LDI</td>
<td>HW FLOW PROOF (HX #1)</td>
</tr>
<tr>
<td>HV</td>
<td>LAO</td>
<td>STEAM VALVE (HX #1)</td>
</tr>
<tr>
<td>HWR</td>
<td>LAI</td>
<td>HW RETURN TEMP (HX #1)</td>
</tr>
<tr>
<td>HWS</td>
<td>LAI</td>
<td>HW SUPPLY TEMP (HX #1)</td>
</tr>
<tr>
<td>IV</td>
<td>LAO</td>
<td>HW ISO VALVE (HX #1)</td>
</tr>
<tr>
<td>PRI-HWR</td>
<td>LAI</td>
<td>PRI HW RET TEMP</td>
</tr>
<tr>
<td>PRI-HWS</td>
<td>LAI</td>
<td>PRI HW SUP TEMP</td>
</tr>
<tr>
<td>FLW</td>
<td>LDI</td>
<td>HW FLOW RET TEMP (HX #2)</td>
</tr>
</tbody>
</table>
Typical Physical Points - Chilled water system fed from the CUP

<table>
<thead>
<tr>
<th>Subpoint Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC-DP</td>
<td>LAI</td>
<td>SEC CHW DP</td>
</tr>
<tr>
<td>CHWB</td>
<td>LAI</td>
<td>PRI CHW BYP TEMP</td>
</tr>
<tr>
<td>CHWR</td>
<td>LAI</td>
<td>PRI CHW RET TEMP</td>
</tr>
<tr>
<td>CHWRV1</td>
<td>LAO</td>
<td>PRI CHW RET VALVE</td>
</tr>
<tr>
<td>CHWRV2</td>
<td>LAO</td>
<td>PRI CHW RET VALVE</td>
</tr>
<tr>
<td>CHWS</td>
<td>LAI</td>
<td>PRI CHW SUP TEMP</td>
</tr>
<tr>
<td>PRI-DP</td>
<td>LAI</td>
<td>PRI CHW DP MAIN</td>
</tr>
<tr>
<td>FLW</td>
<td>LAI</td>
<td>PRI CHW FLOW</td>
</tr>
<tr>
<td>ALM</td>
<td>LDI</td>
<td>CHW VFD ALARM (PUMP #1)</td>
</tr>
<tr>
<td>ENA</td>
<td>LDO/LDI</td>
<td>CHW VFD ENA (PUMP #1)</td>
</tr>
<tr>
<td>HND</td>
<td>LDI</td>
<td>CHW VFD HOA (PUMP #1)</td>
</tr>
<tr>
<td>HZ</td>
<td>LAI</td>
<td>CHW VFD HERTZ (PUMP #1)</td>
</tr>
<tr>
<td>LDI</td>
<td>LDI</td>
<td>CHW VFD LDI (PUMP #1)</td>
</tr>
<tr>
<td>LDO</td>
<td>LDO</td>
<td>CHW VFD LDO (PUMP #1)</td>
</tr>
<tr>
<td>SPD</td>
<td>LAO</td>
<td>CHW VFD SPEED (PUMP #1)</td>
</tr>
<tr>
<td>ALM</td>
<td>LDI</td>
<td>CHW VFD ALARM (PUMP #2)</td>
</tr>
<tr>
<td>ENA</td>
<td>LDO/LDI</td>
<td>CHW VFD ENA (PUMP #2)</td>
</tr>
<tr>
<td>HND</td>
<td>LDI</td>
<td>CHW VFD HOA (PUMP #2)</td>
</tr>
<tr>
<td>HZ</td>
<td>LAI</td>
<td>CHW VFD HERTZ (PUMP #2)</td>
</tr>
<tr>
<td>LDI</td>
<td>LDI</td>
<td>CHW VFD LDI (PUMP #2)</td>
</tr>
<tr>
<td>LDO</td>
<td>LDO</td>
<td>CHW VFD LDO (PUMP #2)</td>
</tr>
<tr>
<td>SPD</td>
<td>LAO</td>
<td>CHW VFD SPEED (PUMP #2)</td>
</tr>
<tr>
<td>CHWR</td>
<td>LAI</td>
<td>SEC CHW RET TEMP</td>
</tr>
<tr>
<td>CHWS</td>
<td>LAI</td>
<td>SEC CHW SUP TEMP</td>
</tr>
<tr>
<td>FLW</td>
<td>LAI</td>
<td>SEC CHW FLOW</td>
</tr>
</tbody>
</table>

Typical Physical Points – Energy/Water Metering

<table>
<thead>
<tr>
<th>SUBPOINT NAME SUFFIX</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWH</td>
<td>LPACI</td>
<td>ELECTRIC CONSUMPTION (NOTE: PREFIX)</td>
</tr>
<tr>
<td>KW</td>
<td>AI</td>
<td>ELECTRIC DEMAND (NOTE: PREFIX)</td>
</tr>
</tbody>
</table>
**FOR ALL BAS VFDS**

<table>
<thead>
<tr>
<th>SUBPOINT NAME</th>
<th>TYPE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALM</td>
<td>LDI</td>
<td>* VFD ALARM</td>
</tr>
<tr>
<td>ENA</td>
<td>LDO/LDI</td>
<td>* VFD ENA (THE START/STOP IS THROUGH COMMUNICATION AND THE STATUS IS HARDWIRED)</td>
</tr>
<tr>
<td>HND</td>
<td>LDI</td>
<td>* VFD HOA</td>
</tr>
<tr>
<td>HZ</td>
<td>LAI</td>
<td>* VFD HERTZ</td>
</tr>
<tr>
<td>LDI</td>
<td>LDI</td>
<td>* VFD LDI</td>
</tr>
<tr>
<td>LDO</td>
<td>LDO</td>
<td>* VFD LDO</td>
</tr>
<tr>
<td>SPD</td>
<td>LAO</td>
<td>* VFD SPEED</td>
</tr>
</tbody>
</table>

### 1.4 SEQUENCE OF OPERATIONS

#### A. Secondary Chilled Water – Control Sequence

1. Chilled water pumps shall function in normal power mode. One pump (lowest run time) shall be functional in emergency power mode. Emergency power is limited, so BAS shall not allow other pumps to run.

2. Space cooling shall be provided via circulation of chilled water as provided by chilled water from central plant. Chilled water pumps are designed to as a parallel pumping system (n+1 redundancy).

3. Each chilled water pump is to have a hand-off auto (h-o-a) switch; units shall be in auto position when available for operation as controlled by the BAS.

4. The chilled water system shall operate at all times.

5. BAS shall alternate pumps weekly on Tuesday at 11:00 am based upon runtime, sequencing equipment in order of least to greatest accumulated yearly runtime, where the lowest runtime unit is indexed as lead/first, and highest runtime unit is indexed as lag/standby.

6. If units selected as duty pumps are unavailable for operation due to maintenance, failure, or selection of off position at unit (h-o-a) switch, the standby pump shall become one of the duty pumps.

7. During low water flow conditions, the large pumps shall be sequenced off and the smaller pump shall be energized to maintain required flow and temperature drop across the heat exchanger.

8. Upon failure of one of the duty chilled water pump, the BAS shall automatically initiate the startup of the standby pump, and signal an alarm to the bas.

9. Chilled water pump flow shall be maintained continuously.

10. Each pump shall be provided with a current sensor to operate as a flow proof of that pumping unit. Any pump energized through the EMS system which does not give positive indication of flow shall signal an alarm after 90 seconds. Continued lack of flow proof for an energized pump to a period of 180 seconds shall de-energize that pump and initiate the startup of the standby unit.

11. Two differential pressure sensors will provide input to the BAS. Each sensor shall have an adjustable set point (provided by TAB contractor). The BAS shall modulate the VFD's of both duty pumps to maintain dp setpoint for both sensors by calculating the difference between each sensor and its set point. The maximum difference shall be input into the VFD control loop.

12. Modulate the 1/3 and 2/3 two way control valves in sequence in the CUP chilled water return line to maintain a CUP CHWR flow set point measured at the chilled water meter. The CUP CHWR flow set point is varied to maintain the required the bldg CHWS temperature set point. Max flow shall be 2700 gpm (adj.) And min flow shall be 25 gpm (adj.).

13. Bldg CHWS temperature is modulated to maintain CUP CHWR temperature set point. Max set point shall be 47°F.
14. Return water temperature set point shall be 56°F (adj.) Or 0.1°F less than bldg CHWR temperature, whichever is greater. CUP CHWR temperature may float below 56°F in order to maintain the bldg CHWS maximum set point of 47°F.

15. In addition to the components and sequences described, provide an independent campus plant chilled water metering system. System shall consist of TC contractor provided chilled water flow meter, temperature transmitters and BTU totalizing meter.

16. Energize pony chilled water pump at low load conditions.

B. Hot Water – Control Sequence

1. One heating water pump (lowest run time) shall function in emergency power mode.
2. Space heating shall be provided via circulation of hot water as provided by a steam to hot water converters. Hot water pumps are designed to operate as duty-standby units for circulation of heating hot water to all points of use.
3. Each hot water pump is to have a hand-off auto (h-o-a) switch; units shall be in auto position when available for operation as controlled by the BAS.
4. Upon a call for heating, either by any air handler units, lab AHU's, cabinet unit heater, fan coil unit, terminal box or unit heater, the following shall occur.
   a. Pumps shall lead/lag on a weekly basis based upon runtime. (one pump is duty and one pump is stand-by)
   b. BAS shall alternate pumps weekly on Tuesday at 11:00 am based upon runtime, sequencing equipment in order of least to greatest accumulated yearly runtime, where the lowest runtime unit is indexed as lead/first, and highest runtime unit is indexed as lag/last.
   c. If unit selected as duty pump is unavailable for operation due to maintenance, failure, or selection of off position at unit (H-O-A) switch, the standby pump shall become the duty pump.
5. Upon failure of the duty hot water pump, the BAS shall automatically initiate the start-up of the standby pump, and signal an alarm to the BAS.
6. Hot water pump flow shall be maintained until there are no systems requesting heating. Each pump shall be provided with a current sensor to operate as a flow proof of that pumping unit. Any pump energized through the EMS system which does not give positive indication of flow shall signal an alarm after 90 seconds. Continued lack of flow proof for an energized pump to a period of 180 seconds shall de-energize the pump and initiate the startup of the standby unit.
7. Two differential pressure sensors will provide input to the BAS. Each sensor shall have an adjustable set point (provided by TAB contractor). The BAS shall modulate the VFD's of both duty pumps to maintain DP setpoint for both sensors by calculating the difference between each sensor and its set point. The maximum difference shall be input into the VFD control loop.
8. Heating hot water heat exchangers shall function in both normal and emergency power modes.
9. Hot water for the heating system described above is to be provided by the steam to heating hot water converter. This is a shell and tube vertical unit served by steam routed from the central plant.
10. The two heat exchangers shall operate simultaneously. Upon initiation of heating system, the steam isolation valves shall slowly ramp open, and exchanger circulation pumps energized. The heat exchanger shall modulate condensate control valves to maintain hot water supply temperature based on an outdoor reset schedule. The ratio shall be 180°F HW at 5°F of outside air and 130°F HW at 60°F of outside air (field adjustable).
11. Close steam isolation valve if discharge water temperature is +15°F (adj.) From setpoint, or on loss of water flow. Alarm BMS.
12. Upon a loss or inability to maintain hot water supply temperature, an alarm shall signal the BAS.
13. Incoming steam supply temperature and flow rate shall be monitored and totalized by the B.A.S. Provide vortex shedding type meter.
14. Snow Melt:
   a. The control panel shall continuously monitor the snow/ice sensor located in the slab. When snow, ice, or water are detected the melting mode shall be initiated, unless the warm weather or cold weather cut-off controls have been activated.
   b. The snow melt zone shall enter the warm weather cut-off mode if the outdoor air temperature is above the melting temperature setpoint. It shall remain in this mode until the
outdoor air temperature drops below the melting temperature setpoint. The warm weather cut-off mode shall deactivate the snow melt zone. The snow melt system shall enter the cold weather cut-off mode if the door air temperature falls below the cold weather cut-off setpoint. The cold weather cut-off mode shall deactivate the snow melt system.

c. The melting mode shall be capable of being activated either through the snow/ice sensor or through a remote signal. The control valve shall be energized when the melting mode is activated and the heat relay shall operate the control valve to maintained the slab surface at the melting temperature setpoint.

d. Maintain the slab at an idling temperature when the snow melt system is not in the melting mode. Control operation is similar to the melting mode except the slab is maintained at a higher idling temperature setpoint.

e. Alarm BMS if a sensor fault occurs.

f. Desired slab surface melting temperature, slab surface idling temperature, and cold weather cut-off temperature setpoints shall be adjustable.

C. Standard VAV AHU Sequence of Operation:

1. The variable volume air handling unit consists of a mixed air section with outdoor air, exhaust air and return air dampers, air blenders, pre-filter, preheat coil, evaporative section, cooling coil and supply and return fans with variable frequency drives. The unit is DDC controlled using electric actuation.

2. The occupancy mode (Occupied or Unoccupied) shall be determined through a user-adjustable, graphical, seven-day schedule with a holiday schedule. The start time shall be adjusted by a Start-Stop-Time-Optimization algorithm such that the unit is started at the latest possible time to allow the space temperatures to be at the occupied set point at the time of occupancy.

3. Before the Occupied mode, the system can enter the Morning Warm-Up mode when the space temperature is below set point or the Cool-Down mode when the space temperature is above set point. The system stays in the Warm-Up or Cool-down mode until the mode set point is satisfied or until the Occupied mode. Within the Unoccupied mode, Night-Heating and Night-Cooling is available when the space temperature drops below 65° F or is above 85° F. The latest start time is the scheduled occupancy for the space.

4. The air handling unit operates in Warm-Up, Cool-Down, Occupied, Unoccupied, Night-Heating, Night-Cooling and modes as follows with adjustable set points and settings.

5. Occupied mode:

6. The air-handling unit shall be controlled by a local dedicated DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.

7. Current-sensing relays shall be provided for status indication at each supply and return fan of each air handling unit.

8. The supply fan variable frequency drive modulates to maintain a constant duct static pressure of 1.0 in WC as sensed at least two-thirds of the way downstream of the supply fan in the longest or most critical duct. The static pressure set point shall be reset so that at least one of the VAV boxes is at 90% of its CFM flow set point and is maintaining its space temperature set point. In the event of loss of communication with any VAV controllers the system shall not include them in the calculation. The calculation will have capability to select how many boxes are used in the routine to deal with problem VAV controllers. A high limit function shall reduce the supply fan speed to keep the supply duct pressure from exceeding 1.0 in WC above the scheduled total fan static pressure or the test and balance setpoint, regardless of the demand from the VAV boxes. Whenever the supply fan is energized the return fan shall be energized. Air flow measuring station input to the BAS shall continuously monitor outside, return and supply air flow during unit operation.

9. The return fan speed shall be modulated through the local control panel and variable frequency drive to maintain a fixed percentage offset set point (adjustable) from the supply fan or building static pressure, which ever variable is greater. Provide building static pressure sensors for each AHU.

10. The primary discharge air set point is reset based upon demand from the space. The primary discharge air set point shall be reset so that at least one of the VAV boxes is at 90% of its cooling
flow set point and is maintaining its space temperature set point. In the event of loss of communication with any VAV controllers the system shall not include them in the calculation. The calculation will have capability to select how many boxes are used in the routine to deal with problem VAV controllers.

11. There shall be a primary discharge air control loop that resets the set points for individual loops for controlling the preheat coil temperature, mixed air temperature, evaporative section temperature and cooling coil temperature.

12. The preheat coil loop will modulate the preheat coil loop based upon the preheat coil temperature versus the preheat coil temperature set point which is reset from the primary temperature set point loop minus 3°F. The preheat coil loop shall have low and high limits (adjustable). Ramp the setpoint from high to low upon start-up when the outside air temperature is below 40°F.

13. The preheat coil pump shall start when the outside air temperature is below 40°F or if the preheat coil valve is open 10 percent. The preheat coil pump shall be off when the outside air temperature is above 45°F and the preheat coil valve is open less than 5 percent for 5 minutes.

14. The mixed air section loop will modulate the mixed air dampers based upon the mixed air temperature set point which is reset from the primary temperature set point loop. The mixed air loop shall have low and high limits (adjustable). Economizer operation shall be disabled when the outside air temperature is greater than the return air temperature with a dead-band of 2°F. Whenever the air handling unit supply fan is enabled, the mixed air dampers shall modulate to maintain a minimum outside air CFM.

15. CO2 sensors should be in all spaces that congregate people and the VAV box ventilation should be increased to control CO2 to maintain 900 PPM while maintaining temperature control. If the air handler is controlling a global CO2 sensor, then the minimum ventilation should be raised to maintain a maximum CO2 setpoint.

16. The evaporative cooling shall operate continuously as long as there is a call for cooling, except when there is a high humidity condition or during the dry out cycle. The outside air damper will be fully open whenever the evaporative section is in operation. The evaporative cooling pump shall operate when the outside air is above 55 deg f (adj.), supply fan is on, the calculated outside air dew-point temperature is below 50 (adj.) & the float switch has made, the sump is full, and there is a call for cooling. Provide 2 vertical sections on evaporative unit with pumps. On call for cooling, stage pump one on. If temperature is more than 3 deg f above setpoint for 10 minutes, stage pump two on. Provide minimum on and off timers that are adjustable for each pump. Pumps shall be interlocked with manufacture provided level switch to de-energize the pumps when the water level is low. If any space humidity is above 50% (adj.) then turn off stage 2, if any space humidity is above 54% (adj.) then turn off stage 1. After a high humidity condition ramp the chilled water valve closed and re-enable the evaporative cooling.

17. The evaporative cooling sump shall drain down when the outside air temperature is less than 40 deg f (adj.) for more than 30 minutes. The sump shall only fill when the outside air temperature is above 55 deg f (adj.) for more than 30 minutes and there is a call for cooling. Provide a 15 minute (adj.) delay to allow the sump to fill before enabling pumps.

18. There shall be a daily dry-out cycle of 60 minutes (adj.) during a university specified period of time (default of 2:00 am). Additionally, a weekly sump drainage cycle shall coincide with the dry-out cycle. Initiate dry-out only if evaporative section has been on for more than one hour (adj.) or more in the previous 24 hours. Initiate bleed if conductivity probe measures 1200 ppm, close drain-valve at 900 ppm. Locate probe in sump.

19. The cooling coil loop will modulate the cooling coil loop based upon the discharge air temperature set point which is reset from the master loop. The cooling coil loop shall have low and high limits (adjustable).

20. On detection of smoke from the unit or duct-mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off and the mixed air dampers shall close. The cooling coil valve will be closed and the preheat coil shall modulate to maintain a preheat set point of 70°F when the outside air temperature is below 35°F. An alarm shall be sent to the BAS.

21. On detection of low or high static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off, the mixed air dampers shall close 100% to the outside air. The cooling coil valve will be closed and the preheat coil shall modulate to maintain a preheat set point of 70°F
F when the outside air temperature is below 35° F and will be open a minimum position relative to the outside air temperature. An alarm shall be sent to the BAS.

22. Upon detection of low limit trip of the freeze-stat the supply and return fans shall stop and the mixed air dampers shall close. The cooling coil valve will open 10 percent and the preheat coil shall modulate to maintain a preheat set point of 70° F. Provide alarm to BAS.

23. Upon sensing excessive pressure differential across each filter bank (pre-filter and final filter), an alarm shall be sent to the BAS. Coordinate setpoints with test and balance contractor during start-up of the system.

D. Unoccupied mode:
1. The supply and return fans shall stop and the mixed air dampers will close to the outside air, and the cooling coil valve will be closed. The preheat coil shall modulate to maintain a preheat set point of 70° F when the outside air temperature is below 35° F and will be open a minimum position relative to the outside air temperature.

E. Morning Warm-Up:
1. If the space is below the occupied temperature set point and the outdoor air temperature is below 35° F, Morning Warm-Up shall be initiated by the Start-Stop-Time-Optimization algorithm. The optimum start-stop program shall start the unit at the latest possible time. The supply fan and return fan will be enabled and operate per the Occupied mode and mixed air dampers and cooling coil valve shall be closed during the Morning Warm-Up cycle. If the space temperature is below set point, the unit shall warm the space to set point by raising the unit discharge temperature to 70° F until the space is satisfied.
2. When the space has reached set point, the unit shall operate in the occupied mode. If occupancy occurs before the space reaches the heating set point, the system switches to occupied mode. Morning warm-up shall occur only once in a day.

F. Morning Cool-Down:
1. If the space is above the occupied temperature set point and the outdoor air temperature is above 60° F, Morning Cool-Down shall be initiated by the Start-Stop-Time-Optimization algorithm. The optimum start-stop program shall start the unit at the latest possible time. The supply fan and return fan will be enabled and operate per the Occupied mode and mixed air dampers and cooling coil valve shall modulate during the Morning Cool-Down cycle. The heating valve shall be closed and if the space temperature is above set point, the unit shall cool down the space to set point by lowering the unit discharge temperature to 55° F until the space is satisfied.
2. When the space has reached set point, the unit shall operate in the occupied mode. If occupancy occurs before the space reaches the heating set point, the system switches to occupied mode. Morning Cool-Down shall occur only once in a day.

G. Night Heating:
1. If the space is below the unoccupied temperature set point and the outdoor air temperature is below 35° F, Night Heating shall be initiated by the Start-Stop-Time-Optimization algorithm. The supply fan and return fan will be enabled and operate per the Occupied mode to maintain a minimum space temperature of 65° F and shall operate until the coldest space is 4° F above the unoccupied set point. The mixed air dampers remain closed to the outside air and the cooling coil valve remains closed. The heating shall modulate to maintain a supply air temperature set point of 70 ° F.

H. Night Cooling:
1. If the space is above the unoccupied temperature set point and the outdoor air temperature is above 60° F, Night Cooling shall be initiated by the Start-Stop-Time-Optimization algorithm. The supply fan and return fan will be enabled and operate per the Occupied mode to maintain a maximum space temperature of 85° F and shall operate until the warmest space is 4° F below the unoccupied set point. The heating valve shall be closed and the mixed air dampers and cooling coil valve shall modulate to maintain supply air temperature set point of 55° F.
I. Lab Variable Volume MAU Air Handling Unit - Control Sequences

1. Under Emergency Power Mode:
   a. De-energize all other supply fans, set drives to 0 hertz.
   b. Set cooling coil control valve to closed position.
   c. When OSA is above 45 deg F, set heating control valve(s) to closed position for units that do not run.
   d. When OSA is 45 deg F or below, steam valve to open relative to heat recovery temperature and heating coil temperature to maintain heat in plenum with face and bypass closed.
   e. Shut all intake and supply dampers

2. The System Consists Of:
   a. Inlet section with isolation damper
   b. Merv 8 and Merv 14 filters
   c. Heat recovery coil
   d. Steam heating coil with 1/3, 2/3 modulating valves with integral face and
   e. Bypass dampers
   f. Evaporative cooling section
   g. Plenum fan with frequency inverter
   h. Chilled water coil with two way modulating valve
   i. Discharge section with isolation damper.
   j. Distributed variable volume terminal boxes
   k. Building exhaust fans (lab and general exhaust).
   l. Separate dual return/relief fans will be provided as part of the system.
   m. Smoke detectors

3. Provide for the air handler unit a controller containing all the required points for successful operation in accordance with these sequences. Provide a data jack at the controller to interface with user.

4. These air handlers will work in parallel supplying a manifolded ductwork system. The units shall operate as a single system, in unison as one fan system at all times.

5. A “watchdog” software algorithm using a matching pair of I/O points between the control panels in the building will be incorporated and used to determine if network communication is available and switch the control panel to local mode if a loss of communication is detected. In local mode all systems turn on and use sensors local to that control panel.

6. The supply fan will operate continuously; the frequency inverter will modulate maintain the duct static pressure as determined by the tab contractor. Locate duct static sensor 2/3 of distance to farthest VAV box in each supply riser. Locations were submitted for review. BAS shall monitor supply duct static pressure readings from each of the supply duct static pressure sensors located in each of the supply shafts. The BAS shall use PID loop control to adjust fan speed to satisfy sensors with the lowest speed possible. Each sensor shall have an adjustable set point (provided by TAB contractor). The BAS shall modulate the VFD's in unison to maintain a static setpoint for each sensor by calculating the difference between each sensor and its set point. The maximum difference shall be input into the VFD control loop. If a sensor fails, then transfer operation to other sensors.

7. The heat recovery coil, heating coil, cooling coil and evaporative section work in concert to maintain a constant discharge air temperature 55 deg F (adj.). The AHU shall maintain a 55 deg F (adj.) set point by resetting the individual set points for each section using one master loop and individual section loops. Each section will maintain a set point in order to maintain the final discharge air set point. Each section will have high and low limits (adj.). Upon a failure of any control section temperature element, transfer control function to adjacent AHU that is in operation and the associated alarming.

8. Heat Recovery: Enable the heat recovery system when the OSA temperature is 40 deg F <OSA> 70 deg F. Each heat recovery pump is to have a hand-off-auto (H-O-A) switch. Units shall be in "auto" position when available for operation for control by BAS. Upon a call for heat recovery, both pumps shall be energized per balancing requirements. Lead/lag the pumps on a weekly basis based upon runtime. The 3-way valve shall be closed when the pumps are off. During heating, modulate to maintain heat recovery setpoint of the heat recovery coil (see item f). If fluid
temperature to exhaust coils is 35 deg F or lower, override the individual 3-way valve control to
maintain minimum fluid temperature of 35 deg F. During cooling, open the 3-way to 100%.
9. Heating Coil: On a call for heat, modulate steam valve to maintain heating coil setpoint (damper in
full bypass). If steam valve is 100% open and heating coil setpoint cannot be maintained,
modulate face and bypass dampers. Steam valve shall be 100% open when entering air
temperature is below 36 deg F or outside air temperature is below 32 deg F for freeze protection.
Ramp the setpoint from high to low upon start-up when outside air temperature is below 40 deg F.
10. Cooling Coil: On a call for cooling, modulate cooling valve to maintain cooling coil setpoint. The
setpoint will be compensated due to the approach across the evaporative cooling section and the
steam humidification coil.
11. The evaporative cooling pump shall operate when the outside air is above 52 deg F (adj.), supply
fan is on, the calculated outside air dew-point temperature is below 50 (adj.) and the float switch
has made. Provide 3 vertical sections on evaporative unit with pumps. The middle section will be
Stage 1, the outside sections will be Stage 2, the outside and middle sections will be Stage 3. On
call for cooling, turn on stage one. If DAT is more than 3 deg F above setpoint for 10 minutes
(adj.), turn on Stage Two. If DAT is more than 3 deg F above setpoint for 10 minutes (adj.), turn
on Stage Three. If any space humidity is above 50% (adj.) then turn off Stage 3, if any space
humidity is above 53% (adj.) then turn off Stage 2, if any space humidity is above 56% (adj.) then
turn off Stage 1. After a high humidity condition ramp the chilled water valve closed and re-
enable the evaporative cooling. Vivarium AHU only – during temperate outside air conditions
allow for the cooling coil to operate due to the swings in discharge air temperature.
12. The sump shall only fill when the outside air temperature is above 50 deg F (adj.) for more than 30
minutes and there is a call for cooling. Provide a 15 minute (adj.) delay to allow the sump to fill
before enabling pumps.
13. There shall be a daily dry-out cycle of 60 minutes (adj.) during a university specified period of
time (default of 2:00 am). Additionally, a weekly sump drainage cycle shall coincide with the dry-
out cycle. Initiate dry-out only if evap. section has been on for more than one hour (adj.) or more
in the previous 24 hours. Initiate bleed if conductivity probe measures 1200 ppm, close drain-
valve at 900 ppm. Locate probe in sump. Locate bleed valve as gravity feed from the sump and
not off the discharge of the pumps.
14. Monitor and alarm differential pressure drop across all filters of all air handlers. Coordinate
setpoints with test and balance contractor during start up.
15. If there is no general exhaust, AHU to stop. Upon failure of supply system, exhaust fans to
operate at fail safe setting of 30%.
16. Runtime hour totalization shall remain in the BAS for each unit. Upon a signal to switch to a
reduced unit operation the BAS shall de-energize the unit with the highest runtime hours total at
that time. Supply fan shall stop and the isolation dampers shall shut. Remaining unit(s) operation
shall adjust to maintain duct static pressure by slowly ramping up to speed as is required to meet
duct static pressure setpoint
17. Air handler operation shall continue until system duct static setpoint is no longer satisfied or until
such time VFDs reach 95% for 10 minutes. At this time, an additional AHU shall be brought
online into parallel operation. Upon a signal to bring on an additional AHU, the BAS shall select
the unit with the lowest runtime to active. The BAS will bring operating AHU supply fan speed to
the minimum value by slowly and evenly decreasing drive speed. At that time, initiate the
additional AHU by opening its isolation dampers and slowly accelerating speed, increase speed to
match the operating AHUs speed. AHU fans in parallel should then operate in unison gradually
accelerating and decelerating under PID control to match duct static pressure requirements of the
system. If the duct static setpoint is satisfied, VFDs are under 65% for 10 minutes. At this time,
an AHU with the lowest runtime will be subtracted and taken offline.
18. Should an AHU fail or be taken out of service, the remaining units shall operate as a single unit
and signal an alarm at the BAS. Should the BAS detect that no units have been added or removed
from staging in over 7 days, the BAS shall index an additional unit on (if available), and then
allow the staging algorithm to determine if the highest runtime unit can be removed from
operation.
19. Supply fan shall stop when:
a. Inlet or outlet isolation damper has not proven open position by hard wired interlock to variable frequency drives
b. On low static pressure alarm
c. On high static pressure alarm
d. Activation of smoke detector or upon signal from the fire alarm system shall initial AHU shutdown
e. The stop / auto interlock is open
f. The VFD is in a fault condition.

20. Upon shut down, the heating and cooling valves shall be closed, the evaporative cooling section shall stop and the isolation dampers shall close.

21. When OSA is above 45 deg F, set heating control valve(s) to closed position for units that do not run

22. When OSA is 45 deg F or below, steam valve to open relative to heat recovery temperature and heating coil temperature to maintain heat in plenum with face and bypass closed.

23. On no lab/ general exhaust - stop all AHUs

24. On low temperature alarm open heat recovery valve to 100% and cooling coil valve to 30%.

J. Demand Control Ventilation (DCV) CO2 Control Sequence
   1. When the CO2 measured in the room is higher than the CO2 setpoint for 30 seconds the program forces the VAV box controller to the heating mode and takes over control of the flow setpoint using proportional integral loop statements. A space cooling loop starts its calculations at the box cooling loop output value and uses the room temperature and the day cooling setpoint to calculate flow. The CO2 loop is based on the CO2 measurement and setpoint. The box flow setpoint is set at the higher of the two loops. Any additional boxes that serve the same room are also forced to the heating mode and the flow setpoints are set to the same percentage as the master box. If the CO2 measurement is more than 100 PPM below the setpoint for more than five minutes then control is returned to the box controllers.

K. Terminal Box Control Sequences:
   1. Variable Air Volume Supply with Reheat (General): The thermostat shall control the damper operator on the variable volume, pressure independent terminal box to a position not exceeding the limits of the scheduled air quantities. On a rise in temperature above the cooling setpoint the damper shall modulate in-between the minimum and maximum CFM schedule value to maintain the cooling setpoint. On a drop in room temperature below the thermostat cooling set point, the thermostat shall modulate the airflow to the minimum scheduled air quantity, to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the controller shall modulate the reheat coil control valve and maintain the index the damper in-between minimum and maximum after the vale is open 100% On rise in temperature above the thermostat heating set point, the thermostat shall close the two-way control valve and modulate the airflow between the minimum and maximum scheduled air quantity.

   2. Temperature Control
      a. Occupied setpoints = 70F to 75F (adj.).
      b. Unoccupied setpoints = 65F to 80F (adj.).

   3. In spaces that are equipped with occupancy sensors for lighting and HVAC control, the VAV box damper and reheat valve shall close when the occupancy sensor determines vacancy and the temperatures are between the setpoints stated above.

   4. In spaces with BAS scheduled occupancy the damper and heating valve shall be closed when unoccupied and room temperature us between the room temperature setpoints. If the entire space is scheduled a minimum number of dampers will stay open to prevent high duct static if the air handler is running.

   5. VAV reheat valve shall be closed when the connected air handler is off

L. Lab Area Sequence of Operation
   1. General
      a. All supply and exhaust VAV boxes that serve one lab area shall be programmed to be able to track the total cfm in a lab area.
b. The supply VAV boxes shall communicate with the exhaust VAV boxes to maintain a volumetric offset in order to keep the laboratory space negative relative to the adjacent space(s).

c. Occupied lab areas shall have an ACH rate from a minimum of 6 ACH to a maximum of (design) ACH.

d. Unoccupied areas shall have constant ACH of 4 and can revert back to occupied rates if the unoccupied setpoints cannot be maintained.

e. A flush mode of 10 ACH shall occur if the lab area has been at unoccupied ACH for more than 1 hour.

f. The priorities for controlling equipments are as follows:
   1) Pressurization
   2) Ventilation
   3) Temperature control

g. The ACH rate for a lab area is based upon the total area enclosed by walls and doors.

h. All fume hoods are to be VAV, when possible.

  i. VAV Size | Minimum velocity in FPM | Minimum CFM
  6”    | 260       | 50
  8”    | 260       | 90
  10”   | 275       | 150
  12”   | 320       | 250
  14”   | 320       | 340
  16”   | 320       | 445

j. Provide fan coil units in Linear Equipment Rooms for process cooling of constant temperature loads.

2. Occupied mode:
   a. Occupied hours: As determined by occupancy input from lighting system
   b. Each lab area shall maintain a 150 cfm negative pressure differential at each door to Linear Equipment Room or office. If a lab area is calculated by the DDC computer to have less than a 100 cfm negative pressure differential at each door, an alarm shall be generated at the computer.
   c. The Exhaust Air VAV Boxes shall be controlled per the schedules for Unoccupied and Occupied modes (CFM of each box vary based on whether or not a hood is installed in that particular Alcove). The Lab Module Supply Air VAV Boxes shall be controlled based on the offset shown in the schedules. In general, the Lab area air quantities were calculated based on the following formula:
   d. Total Supply CFM = Total Exhaust CFM + [(150 CFM/door)*(# of exit doors)]
   e. As thermostats call for additional cooling in each Module or Alcove, the corresponding Supply Air VAV Box(es) and Exhaust Air VAV Box(es) shall open concurrently (up to maximum flow) to satisfy occupied cooling setpoints in that particular Module or Alcove and maintain volumetric offset.
   f. As thermostats call for additional heating in each Module or Alcove the corresponding Supply Air VAV Box(es) and Exhaust Air VAV Box(es) shall modulate concurrently down to minimum CFM flow, while maintaining pressurization and ventilation, and modulate reheat valve to satisfy occupied cooling setpoints in that particular Module or Alcove and maintain volumetric offset.
   g. If required, all Alcove Supply Air VAV Boxes and Lab Module Exhaust Air VAV Boxes included in the sequence that close the dampers in occupied or unoccupied mode shall have a leakage amount measured at closure. The leakage amounts shall be included in the Lab area volumetric offset calculation. Coordinate leakage test with Test & Balance Contractor.

3. Unoccupied mode:
   a. Unoccupied hours: As determined by occupancy input from lighting system
   b. Alcove Exhaust Air VAV Boxes – Balance per schedule (CFM vary based on # of hoods in each Suite) - ~ 4 air changes per hour.
   c. Alcove Supply Air VAV Boxes – Closed position.
   d. Lab Module Exhaust Air VAV Boxes – Closed position.
e. Lab Module Supply Air VAV Boxes – Balance per schedule (Match exhaust cfm minus offset).

f. Approximate total Lab area air change rate ~ 4.0 air changes per hour. The intent is that the lab is operating in a constant volume mode without adding additional cooling and minimal heating.

g. If the temperature drifts outside of the unoccupied setpoints by 2 degrees the Lab area shall go into occupied mode until unoccupied temperature setpoints are achieved and after 15 minutes in occupied mode reset back to unoccupied mode.

4. Flush out mode:
   a. If the Lab area has been unoccupied for more than 1 hour, and the occupancy sensor establishes occupancy, the lab shall enter the flush out mode before the occupancy mode.
   b. Flush out mode shall be at 10 ACH.
   c. The temperature setpoints for the Flush out mode shall be the same as the Occupied Mode

5. Graphics Overview - Show the following on the Lab area Overview
   a. Show the values from the each controller from the lab, alcove, and fume hood.
   b. Controller, supply CFM setpoint, supply CFM, exhaust CFM setpoint, exhaust CFM, differential CFM setpoint, differential CFM
   c. Show the temperature setpoints for the entire suite
   d. Suite occupied cooling setpoint, occupied heating setpoint, unoccupied cooling setpoint, and occupied heating setpoint.
   e. Show the occupancy inputs for the entire suite
   f. Suite occupancy input (from lighting system), suite override input, suite mode, and suite flush mode
   g. Show the values for the entire suite operation
   h. ACH, total supply, total exhaust, scheduled differential CFM setpoint, differential CFM

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 SEQUENCE PROGRAMMING

A. Sequence logic shall be installed in a professional manor that demonstrates a full understanding of the sequence and maximizes energy conservation and smooth operation in strategies and techniques not covered by the sequence.

B. All setpoints and control parameters shall be adjustable

C. All control loops shall utilize PID control algorithms unless application dictates otherwise.
   1. The proportional and integral values which make up the PID output value shall be readable and modifiable to facilitate tuning of control loops.
   2. All PID loops serving critical equipment shall provide for operator control of loop starting point without program editing when control is returned to program control after being in operator control.
   3. All loops shall have a virtual output in the loop statement to allow knowledge of loop performance before changing output from manual to program control.

D. The outside air temperature sensor and other inputs that are used in multiple programs shall be attached to a single virtual point, which is used in the programs.

E. Mode changes shall be stable. Abrupt changes that cause unnecessary opening of valves should not be used. Example: Do not abruptly change the supply air temperature setpoint when going from warmup mode to occupied mode.

F. All logic statements or blocks shall be input with consistent naming conventions.
G. The logic for separate DDC controllers serving AHUs with identical sequences of operation, shall also be identical.

3.2 INSTALLATION GENERAL

A. All HVAC safeties shall be hardwired such that the shutdown will occur in Automatic and Hand and bypass modes at the BAS system and the starter.

B. Software safeties are not acceptable (exception: smoke control may be done through software if the control system is UL listed for smoke control).

END OF SECTION 23 09 93
SECTION 23 20 00 - PIPING

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Snow Melt
   1. The use of snow melt systems is discouraged because of high energy use.
   2. Snow melting installations are divided into two classes.
      a. Class I: Main pedestrian entrances, walks or driveways on the north side of the buildings.
      b. Class II: Commercial sidewalks and driveways.
   3. Design snow melt systems for areas critical to safety. It is unacceptable to have snow on the snow
      melt surface for any length of time. Consider snow melt systems for sidewalks, loading docks,
      service entrances, main entrances and steps.
   4. Base typical system for 150 Btu-h per square foot with a 10-mph wind at 0 degrees F.
   5. Provide systems with 60 percent water and 40 percent Dowfrost.
   6. Provide dedicated steam to water heat exchanger(s).

B. Pipe Connections: Provide required straight sections for flow measurement stations.

C. Expansion Compensation:
   1. Piping and joints shall be designed to eliminate damage by expansion and contraction.
   2. Mechanical expansion devices are discouraged. Expansion loops are preferred. Where mechanical
      expansion devices are necessary, bellows type shall be specified. Other types with mechanical
      seals are not permitted.
   3. Devices shall be readily accessible for maintenance and repair per the manufacture’s
      recommendations.

D. Natural Gas Piping Systems:
   1. Provide shut-off cocks on all branch lines, and lab benches, and make cocks easily accessible for
      service and operation. Provide drip legs at all equipment connections. Use pipe dope on threaded
      pipe fittings, Teflon tape is prohibited.

E. Sanitary Sewer Piping Systems:
   1. Provide manholes at major junctions of exterior sewer lines, and provide cleanouts on all other
      junctions.
   2. Locate interior clean-out caps and plugs such that they can be removed without damaging the
      surfaces in which they are installed.
   3. Do not discharge chemical waste, oils, antifreeze, and other wastes into the sanitary sewer without
      written approval of the University Project Manager. Coordinate the requirement of acid
      neutralizing systems and sand and oil interceptors with the University Project Manager.
   4. Do not discharge domestic water used for cooling into the sanitary sewer except for emergency
      back up for critical systems and vacuum systems.

F. Storm Drain Piping Systems:
   1. Do not discharge sanitary waste into the storm sewer system. Do not discharge storm drain water
      into the sanitary waste system.

G. Ejector Pumps
   1. At system low points where gravity drain is not possible provide duplex sump pump systems with
      high water alarms connected to Building Automation System. Provide gravity drainage piping
      downstream of pumps sized to accommodate the discharge of both pumps running at the same
      time and any additional load produced from normal gravity drainage.
2. Provide sump pump controls with a manual selectable, alternating relay to switch lead-lag operation.
3. Provide all sump pumps with standby or emergency power.
4. Stainless Rails, chains, etc Removable System…
5. Provide flanged pump connections.

H. Chemical and Acid Waste Systems:
1. Discuss the treatment and handling of chemical and acid wastes with the University Project Manager. Typically, most wastes at the university are collected in containers and are disposed of through the university and the need for acid waste pipe is the exception. Acid wastes may be generated in deionized water systems and in these cases a neutralization system must be approved by the University Project Manager through EH&S and Operations.
2. Where chemical and acid waste is required by specific circumstance and it is virtually inaccessible (i.e., concrete slab) polypropylene pipe should be used in these locations.
3. Waste lines shall be constructed from polypropylene pipe with mechanical joints.
4. Building waste water effluent must meet state and federal regulations.
5. Pretreatment may be necessary based on specific program requirements.
6. Engineer to determine whether pretreatment is recommend based on discussions with program representatives regarding types and amounts of chemicals and other materials with which they will be working.
7. Provide sampling ports building discharge for laboratory effluent systems.
8. Coordinate with regulatory agencies, including Metro Waste Water.
9. Coordinate requirements closely with the University Project Manager.

I. Potable Water Piping System:
1. Lead pipe or lead solder is prohibited for all potable water piping systems.
2. Make domestic water piping joints with lead free solder.
3. Size domestic water piping to maintain maximum velocities of 8 feet per second for cold water and 5 feet per second on hot water and hot water circulation piping.
4. Provide main shutoff valve for potable water inside the building.
5. As a minimum, provide shut-off valves at each branch, floor, equipment and bathroom group.

1.2 QUALITY ASSURANCE

A. Welders Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

B. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as “B31.9 Building Services Piping”.

C. The types and extent of non-destructive examinations required for pipe welds are as shown in Table 136.4 of the ASME Code for Pressure Piping, ANSI/ASME B31.1 - Power Piping. If requirements for non-destructive examination are to be other than that stated above, the degree of examination, and basis for rejection shall be a matter of prior written agreement between the fabricator, of contractor and the purchaser.


E. Welding: All welding work shall be performed by welders certified to ASME or AWS standards within the last year for the type of material and application suited for the job. Contractors shall submit copies of qualification tests of the welders to the Project Manager prior to construction.
F. ASME B31.9 “Building Services Piping” for materials, products and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

1.3 WARRANTY:

A. Manufacturer’s warranty of 25 years for snowmelt tube and 18 months for snowmelt manifolds.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years
   2. Grooved Piping:
      a. ITT Grinnell Corp.
      b. Victaulic Co. of America
   3. Piping Connectors
      a. Fernco, Inc.
   4. Pipe Thread Sealant
      a. The Rectorseal Corp.
   5. Drainage Piping Specialties, including backwater valves, expansion joints, drains, cleanouts, flashing flange and vent flashing sleeve.
      a. JR Smith
      b. Zurn Industries
      c. Wade
      d. Josam
   6. Gas Cocks
      a. Crane
      b. Hammond
      c. Peter Healy

B. Acceptable Manufacturers - Snowmelt: Subject to compliance with requirements, provide products by the following:
   1. Tube, Fittings, Pipe, and Manifolds:
      a. Uponor
      b. Watts Radiant
      c. Quest Hydronics
   2. Controls: Integrated into BAS (preferred)

2.2 MATERIALS, GENERAL - SNOWMELT

A. Provide components of the buried tubing system by one manufacturer, including tubing, fittings, manifolds, and ancillary items.

B. Small Systems, Less Than 5000 Square Feet:
   1. Tube: ASTM F876, cross linked polyethylene, 5/8-inch inside diameter, rated at 180 degree F maximum working temperature and 100 psi working pressure, with oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than 0.10 g/m3/day at 104 degree F. Minimum bend radius for cold bending shall be less than six times the outside diameter.
   2. Fittings: Dezincification resistant brass fittings consisting of a barbed insert, compression ring, and compression nut.
3. Manifolds: Cast brass construction, manufactured of alloys to prevent dezincification, with integral circuit balancing valves. Provide with support brackets and tube bend supports. Isolate manifolds from supply and return tubing with valves suitable for isolation and balancing. Manifolds shall be capable of venting air from the system.

C. Large Systems, Over 5000 Square Feet:
1. Tube: ASTM F1350, cross linked, low density polyethylene without oxygen diffusion barrier. 7/8-inch inside diameter, rated at 140 degree F maximum working temperature and 55 psi working pressure.
2. Fittings: Dezincification resistant brass fittings or HDPE, SDR 11 polyethylene fittings.
3. Manifolds: Pre-manufactured of HDPE, fusion welded, designed for balanced flow. Include proper fittings or compression clamping sleeve and locking caps.

D. Supply and Return Main Pipe:
1. 2 Inch and below: ASTM F876, cross linked polyethylene, rated at 180 degree F maximum working temperature and 100 psi working pressure with oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than 0.10 g/m3/day at 104 degree F.
   a. Fittings: Brass or Bronze
2. Above 2 Inches: Industrial pressure pipe, HDPE polyethylene pipe, fusion welded.
   a. Fittings: HDPE, SDR 11, fusion welded.

E. Access Covers:
1. Removable access covers constructed of reinforced concrete formed in place or precast concrete over pipe connections, fittings, and distribution manifolds. Provide tapered forms for covers. Covers subject to vehicular traffic shall be traffic rated.

F. Controls:
1. Control by Division 23 09 00.

2.3 MATERIALS, GENERAL

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class in not indicated, provide proper selections determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, and valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer’s recommendations where applicable.

C. Steel Pipes and Pipe Fittings:
1. Black Steel Pipe: ASTM A53, Grade B, Type E, electric resistance welded.
2. Galvanized Steel Pipe: ASTM A 53, Grade B.
3. Seamless Steel Pipe: ASTM A53, Grade B, type S or A106 high temperature.
4. Stainless Steel Pipe: ASTM A312; Grade TP 304 (high temperature and corrosive service, 1/8-inch through 30-inch.
6. Cement-Mortar Protective Lining and Coating for Steel Pipe: AWWA.
7. Steel Water Pipe: AWWA for pipe 6-inch and larger.
8. Cast-Iron Flanged Fittings: ANSI B16.1, including bolting (class 125 and 250)
9. Cast-Iron Threaded Fittings: ANSI B16.4; plain or galvanized as indicated (Class 125 and 250)
10. Malleable-Iron Threaded Fittings: ANSI B16.3; plain or galvanized as indicated (Class 125 and 300)
11. Malleable-Iron Threaded Unions: ANSI B16.30, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).
13. Steel Flanges/Fittings: ANSI B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.
14. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing (threaded where pressure is not critical).
15. Forged-steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe up to 4 inch pipe size).
18. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.
19. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less that Schedule 80 pipe where length remaining unthreaded is less that 1-1/2 inch and where pipe size is less than 1-1/2 inch, and do not thread nipples full length (no close nipples).

D. Copper Tube and Fittings:
1. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn, except as otherwise indicated.
2. DWV Copper Tube: ASTM B306
3. ACR Copper Tube: ASTM B280.
6. Cast-Copper Solder-Join Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).
8. Cast-Copper Flared Tube Fittings: ANSI B16.26
9. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300)
10. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

E. Brass Pipe and Fittings:
1. Red Brass Pipe: ASTM B43 (boiler feed pipe, 1/8 inch through 12 inch, regular or extra strong weight)
2. Cast-Bronze Threaded Fittings: ANSI B16.15, Class 125 or 250.

F. Cast-Iron Soil Pipes and Pipe Fittings:
5. Neoprene Compression Gaskets: ASTM C564

G. Grooved Piping:
1. Coupling Housings: Malleable iron conforming to ASTM A47.
2. Coupling Housings: Ductile iron conforming to ASTM A536.
3. Coupling Housings Description: Grooved mechanical type, which engages grooved or shouldered pipe ends, encasing an elastomeric gasket which bridges pipe ends to create seal. Cast in two or more parts, secure together during assembly with nuts and bolts. Permit degree or contraction and expansions specified in manufacturer’s latest published literature.
4. Gaskets: Mechanical grooved coupling design, pressure responsive so that internal pressure serves to increase the seal’s tightness, constructed of elastomers having properties as designated by ASTM D2000.
   a. Water Services: EDPM Grade E, with green color-code identification.
   b. Other Services: As recommended by Manufacturer.
6. Branch Stub-ins: Upper housing with fill locating collar for rigid positioning engaging machine-cut hole in pipe, encasing elastomeric gasket conforming to pipe outside diameter around hole, and lower housing with positioning lugs, secured together during assembly with nuts and bolts.
7. Fittings: Grooved or shouldered end design to accept grooved mechanical couplings.
   a. Malleable Iron: ASTM A47
   b. Ductile Iron: ASTM A536
   c. Fabricated Steel: ASTM A53, carbon steel, Schedule 40, Type F, for 3/4 inch to 4 inch; Type E or S, Grade B for 5 inch to 20 inch.
   d. Steel: ASTM A234
   e. Wrought Copper and Bronze: ASTM B75 tube and ASTM B584 bronze castings.
8. Flanges: Conform to Class 125 cast iron and Class 150 steel bolt holes alignment.
9. Grooves: Conform to the following:
   b. Lightweight Steel: Roll grooved.

H. Miscellaneous Piping Materials/Products:
2. Soldering Materials: Lead-free solder
3. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.
   a. Comply with AWS A5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
      1) Copper phosphorus – Bcup
      2) Silver - BAg minimum 4% Silver content
4. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.
5. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.

I. Piping Systems:
1. Domestic Hot and Cold Water:
   a. Above Grade, Inside Buildings: Type L, hard drawn copper tube with wrought copper or bronze fittings, lead free solder joints or Schedule 40, galvanized steel pipe A53 grade B, ERW w/galvanized Grooved end fittings.
   b. Below Grade, Inside and Outside Buildings: Underground outside fittings shall comply with City of Aurora standards.
      1) 2 inches and Smaller: Type K, soft copper or Type K annealed copper tube with wrought copper fittings, silver brazed solder joints.
      2) 2.5 inches and Larger: Class 250, tar coated outside, cement lined, cast iron or ductile iron with mechanical or push on joints.
2. Equipment drain and overflows: Type “M” or “DWV” copper.
3. Sanitary Sewer and Vents:
a. Above Grade: Service weight cast iron, no-hub type with neoprene gaskets; service weight cast iron, hub and spigot type with neoprene gaskets; or DWV copper with wrought copper or cast brass fittings.
   1) Use heavy duty no hub couplings 4” wide 304 stainless steel shield, with six (6) stainless steel clamps mounted in series on the following:
      a) Sanitary vent piping 4” and larger.
      b) Sanitary piping 3” and larger.
      c) All storm piping.
   2) Torque to minimum 80 inch pounds or per manufacturer’s recommendation.
   3) Acceptable manufacturers: Husky Series 4000 or Mission Heavy Weight.

b. Below Grade: Sizes 2 inches to 20 inches, service weight cast iron, hub and spigot type with neoprene compression gaskets; or sizes 12 inches and larger ductile cast iron with neoprene gasket joints.

c. Cleanout Openings: Two-way type, 1-1/4 inch nominal size minimum and located such that long lines can be entered from both ends. Lubricate plugs at installation.

d. All sump pumps receiving floor drains located in boiler rooms will be non-submersible type. Pumps will be designed to handle hot water because boilers are flushed or emptied at intervals into floor sumps.

4. Storm Drain
   a. Above Grade:
      1) Same as sanitary sewer.
      2) Utilize heavy duty, 8 psi, no-hub couplings for cast iron. No-hub may only be used on piping within 20’ below the roof. This limitation is to prevent a failure of the 8 psi rated couplings in the event of a downstream system blockage. In lieu of this restriction adequate relief or a higher rated fittings, must be provided and approved by the engineer.
      3) Threaded or mechanical couplings with galvanized piping are acceptable for all locations.

   b. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type or sizes 12 inch and larger ductile cast iron with neoprene gasket joints.

   c. Roof drains or drains located in outside areaways, not subject to regular foot traffic, shall be of the dome type to minimize clogging with leaves or other debris.

5. Natural Gas:
   a. Within the Building: Schedule 40 black iron pipe, threaded for sizes 2 inches and smaller and welded for 2-1/2 inch and larger. All lines shall be accessible.
   b. Flex lines to equipment and fixtures shall be stainless steel with epoxy coating on both sides, UL stamped. Other types are prohibited.
   c. Pipe dope shall be Teflon based. Oil based is not permitted. Teflon tape prohibited.

6. Chemical and Acid Waste:
   a. Acid resistant, flame retardant, schedule 40 polypropylene pipe and fittings with electrically-induced or mechanical joints.

J. REFRIGERANT PIPING
1. Line sets are not allowed.
2. Tube Material:
   a. Size 3/4” and smaller: Soft annealed temper copper tube.
   b. Size 7/8” through 4-1/8”: Hard drawn temper copper tube.
   c. Type ACR.
4. Joints: Brazed or soldered with material having shear strength of 10,000 PSI or greater.
5. End Caps:
   a. Provide factory applied plastic end caps on each length of pipe and tube.
   b. Maintain end caps through shipping, storage and handling as required to prevent pipe end damage and eliminate dirt and moisture from inside of pipe and tube.
6. Shut Off Valves:
K. Manufacturers:
1. Henry
2. Other Acceptable Manufacturers:
   a. Parker Hannifin Corp.
   b. Singer
   c. Sporlan Valve Co.
3. Size 7/8 Inch and Smaller:
   b. Type: Pack-less diaphragm.
   c. Material: Forged bronze.
   d. Flow: Non-directional.
   e. Servicing: Diaphragm changeable under line pressure.
4. Size 1-1/8 Inch and Larger:
   b. Type: Wing cap, back seating.
   c. Material: Bronze.

L. Pipe Connectors:
1. Manufacturers
   a. Mason
   b. Metraflex
   c. Flexonics
2. Braided bronze with copper tube ends, compatible with refrigerant type for system
3. Flexible connector shall be line size or connection size, whichever is larger.

M. Piping Specialties:
1. Refrigeration Accessories (Strainers, Moisture-Liquid Indicators, Filter-Driers, Evaporator Pressure Regulators, Discharge Line Mufflers, Expansion Valves, Superheat Adjustment):
2. Manufacturers:
   a. Alco Controls Division, Emerson Electric Co.
   b. Henry Valve Co.
   c. Parker Hannifin Corp.
   d. Sporlan Valve Co.
3. Filter Drier:
   a. Conform to ARI Standard 710.
   b. Sizes ½” and larger - interchangeable core, full flow.
   c. Sizes smaller than ½” - sealed type.
   d. Minimum burst pressure - 1500 psig.
4. Expansion Valve:
5. Thermostatic type, diaphragm or bellows operated.
6. External superheat adjustment factory set for 10ºF superheat (adjustable).
7. Compatible with refrigerant type for the project.
8. Pressure rated per project requirements.
9. Power elements and valve size shall be as recommended by the manufacturer, for the service intended.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.
1. Comply with ANSI B31 Code for Pressure Piping.
2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment shall be allowed.
3. Use fittings for all changes in direction and all branch connections.
4. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
5. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
6. Install drainage piping with a minimum 1/8 inch per foot downward slope in the direction of the drain and a maximum slope of ¼ inch per foot.
7. Install drains at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾-inch ball valve, and short ¾-inch threaded nipple, hose connection, and cap.

B. Piping System Joints:
1. General: Provide joints of type indicated in each piping system.
2. Thread pipe in accordance with ANSI B2.1Braze copper tube-and -fitting joints in accordance with ASME B31.
3. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.
4. Weld pipe joints as follows:
   a. Weld pipe joints only when ambient temperature is above 0 degrees F. (-18 degrees C)
   b. Bevel pipe ends at a 37. 5-degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
   c. Use pipe clamps or tack-weld joints with 1-inch long welds; 4 welds for pipe sizes to 10 inch, 8 welds for pipe sizes 12 inch to 20 inch.
   d. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures, which will ensure elimination of unsound or un-fused metal, cracks, oxidation, blow-holes and non-metallic inclusions.
   e. Do not weld-out piping system imperfections by tack-welding procedures; re-fabricate to comply with requirements.
5. Weld pipe joints of steel water pipe in accordance with AWWA C206.
6. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

C. Pipe Fittings:
1. Place unions at all equipment, regulators, controls, etc., that require removal or replacement. Do not block removal with adjacent equipment or piping. Where necessary for removal of equipment, install unions on both sides of equipment. Unions are not required on flanged devices.
2. Use dielectric waterway fittings where dissimilar metals are connected. Isolate building distribution gas piping with dielectric unions from gas main for cathodic protection.
3. All unions shall be ground joints.
4. Make reductions in size with reducing fittings.
5. All screwed nipples from copper fittings shall be red brass.

D. Pipe Connections: Install pipe connections to pumps, compressors, etc., with adequate allowance for movement and vibration. Support connections so the equipment does not carry weight.

E. Expansion Compensation: Arrange pipes and equipment with due regard for the effects of thermal expansion.

F. Hangers and Supports:
1. Maintain uniform grading and pipe slope of piping system. Install supports between piping and building structure to prevent swaying and vibration. Install hangers to provide a minimum 1/2-
inch clear space between finished covering and adjacent work. Use threaded rods with two lock nuts.

2. Do not support weight of piping from mechanical equipment, ductwork, pump flanges, coil connections, and related items.

3. Support hanger rods by coach screw rods, angle iron clips, or beam clamps. No drilling of structural members will be permitted without approval. Hanger rods shall be attached to the top of joist beams.

4. Do not bend hanger rods to provide alignment of piping offset from overhead supports.

5. Provide sway bracing every 40 feet on cast iron.


7. Vertical Supports
   a. Cast Iron Pipe: Support at each floor, not to exceed 15 feet between supports, and at pipe base.
   b. Screwed Pipe: Support at 8 foot on center for 1-1/2 inch and smaller pipe. Support at 10 foot on center for 2-inch and larger pipe.
   c. Copper Pipe: Support at 6 foot on center for 1-1/2 inch and smaller pipe. Support 8 foot on center for 2-inch and larger pipe.

8. Trapeze Hangers: Space for smallest pipe in-group. Provide additional hanger rod at mid span where trapeze length exceeds 4 feet. Secure pipe at each trapeze with standard pipe strap. Rest uninsulated copper pipe on neoprene sleeves.

G. Pipe Joint Construction:
   1. Soldered Joints: Comply with the procedures contained in the AWS “Soldering Manual”.
   2. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual”.
      CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
   3. Fill all medical gas and refrigerant pipe and fittings during brazing with an inert gas, i.e., nitrogen or carbon dioxide, to prevent formation of scale.
   5. For all copper piping, ream and remove all burrs prior to making joints.
   7. Damaged Threads: Do not use pipe with threads that are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
   8. Welded Joints: Comply with the requirement in ASME Code B31.9 “Building Services piping”.
   9. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

3.2 INSTALLATION, GENERAL - SNOWMELT

A. Secure tubing to wire mesh or rebar every 4 feet along straight runs and on 180 degree turns secure at the top of the arc and on each side, 12 inches from the top of the arc,

B. Install fittings accessible for maintenance. Install tubing loops without splices, as a minimum, from the point at which the tubing enters the panel to the point at which it exists the panels.

C. Pressurize the tubing system with water or air to a pressure of 60 psig 24 hours prior to encasement in the radiant panel. Maintain pressurization during the panel installation and for a minimum of 24 hours after panel installation to ensure system integrity.

D. Label piping, valves, and equipment in accordance with 23 05 53.

E. Drain water or air from the system after leak testing the system and fill with 60 percent water and 40 percent propylene glycol water mix.
F. Do not extend pipe through expansion, construction, or working joints in concrete slab unless specifically addressed during design. Carefully coordinate expansion joints installed during or cut after concrete pour with the tubing layout and snow melt manufacturer.

G. Hydraulically balance mains. Coordinate balancing with Section 23 05 43 and include balancing information in balancing report.

3.3 INSTALLATION, GENERAL – REFRIGERATION

A. Size lines for total pressure drop not to exceed 2° F saturation temperature.

B. Provide necessary flexibility for vibration and expansion with offsets and loops, not expansion joints.

C. Provide flexible connectors at all unit connections.

D. Replace air in pipe with dry nitrogen to prevent corrosion during soldering.

E. Install valves, sight glasses, filter-driers, and accessories, furnished by equipment supplier, but not factory installed.

F. Insulate all underground refrigerant lines with ½” flexible foam.
   1. Use un-slit covering.
   2. Cement all joints.

G. Hangers:
   1. For insulated piping, provide hangers of size to fit outside insulation.
   2. For non-insulated piping, provide hangers with elastomer insert to prevent damage to piping from vibration.

H. Testing:
   1. Use the following procedure to test and hydrate the systems:
   2. Isolate any elements which would be damaged by test pressures.
   3. Test system with trace gas using an appropriate leak detector.
   4. Pressure Test - System shall hold 150 psi nitrogen charge for a 24-hour period.
   5. Repair or replace leaking elements of system and re-test.
   6. After system has been proven to be free of leaks, evacuate it with a high efficiency vacuum pump to 2.5 mm of mercury absolute.
   7. Evacuation - System shall be evacuated to 250 microns, and inspected by a University HVAC representative.
   8. Reak the final vacuum by charging with the correct refrigerant.

3.4 TESTING, CLEANING, AND CERTIFICATION

A. Test all piping systems in accordance with tests outlined in individual sections. Provide temporary equipment for testing, including pump and gages. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Test all new piping and parts of existing piping that have been altered extended or repaired. Submit report(s) on the results of each test.

B. Give a minimum of twenty-four hours notice to the Engineer for dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of the University Project Manager or representative of agency having jurisdiction. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.
C. Compressed air tests may be substituted for hydrostatic tests only when ambient conditions or existing building conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing.

D. Remove equipment not able to withstand test procedure during test.

E. For piping, which is to be concealed, piping shall remain uncovered until tests have been completed.

F. Drain test water from piping systems after testing and repair work has been completed.

G. Repair piping systems sections that fail testing, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics or other temporary repair methods.

H. Potable Water Piping System:
   1. Cap domestic water piping and subject piping to static water pressure of 50 psig above operating pressures or 150 psig maximum without exceeding pressure rating of piping system materials. Allow the system to remain pressurized for 4 hours. Correct leaks and loss in pressure and retest system.
   2. Disinfect all domestic hot and cold water systems upon completion of final piping installation. Following disinfection, flush water from system through its extremities. Continue flushing until samples show quality is comparable with public water supply and complies with requirements of public health authority.

I. Gas Pipe Testing:
   1. Test with air, nitrogen, or carbon dioxide.
   2. Test piping system with a pressure 1-1/2 times the proposed maximum working pressure, but not less than 3 psig. Test systems having a volume of 10 cubic feet or less for a period of not less than 10 minutes and larger systems for a period of not less than 1/2 hour for each 500 cubic foot of pipe volume or fraction thereof without showing any drop in pressure.
   3. Fully purge gas piping after piping has been checked.

J. Sanitary Sewer Pipe Testing:
   1. Test drain, waste, and vent piping on completion of rough in. Close openings in piping system and fill with water to point of overflow but not less than 10 feet of head. Water level must not drop from 15 minutes before inspection starts through completion of inspection. Correct leaks and retest system.

K. Adjusting and Cleaning:
   1. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush piping systems with clean water. Inspect each run of each system for completion of joints, supports and accessory items.
   2. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.
   3. Flush each new extension of existing systems, via hose connections prior to filling. Fill each new extension of existing systems with water that has the proper water treatment chemicals and in the proper quantity prior to connection, or opening valves to the main or existing system. Use chemicals that are compatible with the chemicals in the existing system. Flush each new system with the university representative present. Fill each new system with the proper chemicals, and with the university representative present.

3.5 COMMISSIONING (DEMONSTRATION)
   1. Fill system and perform initial chemical treatment.
2. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

3. Before operating the system, perform these steps:


5. Remove and clean strainers.

6. Check pump for proper rotation and proper wiring.

7. Set automatic fill valves for required system pressure.

8. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

9. Set temperature controls so all coils are calling for full flow.

10. Check operation of automatic bypass valve.

11. Check and set operating temperature of converters and chillers to design requirements.

12. Lubricate motors and bearings.

END OF SECTION 23 20 00
SECTION 23 21 00 - HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Design piping systems with drain valves at low points of piping, bases of vertical risers, and at equipment.

B. In hydronic systems subject to freezing provide Dowfrost solution or pumped coils.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

   1. Valves:
      a. Automatic Fill Valves:
         1) ITT Bell and Gossett, Model B7-12
         2) Amtrol, Model 11F

2.2 MATERIALS, GENERAL

A. Piping and Fittings:

   1. General: Working pressure and temperature maximums, 125 psi and 250 degrees F; water service.
   2. Copper Pipe: ASTM B88-96, copper tubing, hard drawn, Type K for underground lines and Type L for above ground lines.
      b. Joining Material:
         1) Solder: ASTM B32-96, 95-5 tin-antimony solder for above ground lines.
         2) Brazing: AWS A5.8-92, Classification BAg 1 (silver) for underground lines and where copper pipe is connected to brass.
      d. Flanges: Class 125, cast iron or cast bronze flanges.
         1) Bolts and Nuts: ASME B18.2.1-96, carbon steel square head machine bolts with galvanized heavy hex nuts.
         2) Gaskets: ASME B16.21-92, nonmetallic, flat, 1/16-inch, full faced, for water service.
      e. Dielectric Connections: Fittings having insulating material isolating joined dissimilar metals.
         1) Dielectric Waterway Fittings: 175 psi minimum working pressure, ends to match connections.
         2) Flanges: Class 125, cast bronze, ASME Standard, with bolt insulators, dielectric gasket, bolts, and nuts.
      a. Fittings:
         1) Threaded: ASME B16.4-92, Class 125, cast iron, or ASME B16.3-92, Class 150, malleable-iron. Standard pattern for threaded joints. Threads shall conform to ASME B1.20.1-83.
         2) Flanged: ASME B16.1-89, Class 125, cast iron, raised ground face, bolt holes spot faced.
         4) Grooved Couplings and Mechanical Fittings: ASTM A536-84 ductile or ASTM A47-90 malleable iron, with enamel finish and grooves or shoulders designed to
accept grooved couplings. Synthetic-rubber gasket, with central-cavity, pressure-responsive design, and ASTM A183-83 carbon-steel bolts and nuts.


c. Dielectric Waterway Fittings: Threaded end connections. Install to isolate dissimilar metals, prevent galvanic action, and prevent corrosion.

B. Valves:
1. Safety Relief Valves:
   a. Brass or bronze body with brass and rubber, wetted, internal working parts. Valves designed, built, rated, and stamped in accordance with ASME.
   2. Automatic Fill Valve: Diaphragm operated, cast brass body, fill valve designed to maintain water pressure in a closed water system. Valves shall include cleanable strainer, removable seat assembly, and built-in check valve. Valves shall have factory setting of 12 psig with field adjustment range of 10 - 25 psig. Maximum operating temperature shall be 225 degrees F, maximum working pressure of 125 psig. Valve shall have 3/4-inch inlet and outlet.

C. Piping Accessories:
1. Drain Pans: Minimum 18-gauge stainless steel, reinforced to support weight of drain pan and water.

D. Expansion Loop Guides:
1. Factory fabricated cast steel, consisting of bolted two-section outer cylinder and base. Provide two-section alignment guide spider that bolts tightly to pipe.

E. Air Separator:
1. In-Line Air Separator: Heavy duty cast iron air separator constructed for 175 psi minimum working pressure and 300 degree F. Integral weir to maximize air separation. Top outlet connection for air vent and bottom connection for expansion tank.
   2. Centrifugal Air Separator: Welded steel tank, ASME constructed and labeled for 125 psig minimum working pressure and 350 degree F maximum operating temperature. In-the-pipeline type air separator with tangential openings for water in and out. Inside designed to create a low velocity vortex for the separation of free air from the water stream. Internal steel strainer with perforations sized for water flow. 2-inch bottom drain and 1-1/4-inch connection located at top of air separator for expansion tank connection.

F. Diaphragm Expansion Tank:
1. Welded steel tank suitable for 125 psig working pressure and 350 degrees F maximum operating temperature. Separate air charge from system water by means of a flexible diaphragm sealed into tank. Tank shall have taps for pressure gauge, air charge fitting, and drain. Tank constructed, tested, and labeled in accordance with ASME Pressure Vessel Code-95.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Copper Pipe:
1. Install Type L copper pipe with wrought copper fittings and solder joints for 2-inch and smaller pipe, above ground, within building.
   2. Install Type K copper pipe for 2 inch and smaller pipe below ground.

B. Steel Pipe:
1. Threaded Joints: Install steel pipe with threaded joints and fittings for 2-inch and smaller in exposed locations such as mechanical rooms.
   2. Welded and Flanged Joints: Install welded fittings on pipe 2-1/2 inches and larger.
3. Grooved Couplings and Mechanical Fittings: Install mechanical grooved end pipe on condenser water piping.

C. Arrange piping in horizontal groups, each group to be in one plane. Maintain indicated slope. Conceal pipe installations in walls, pipe chases, utility spaces, mechanical rooms, above ceilings, below grade or floors.

D. Install piping in accordance with the stipulations in Section 01040.

E. Sloping, Air Venting, and Draining:
   1. Install piping true to line and grade, and free of traps and air pockets. Slope piping up in direction of flow at 0.2 percent grade.
   2. Provide eccentric reducers for changes in horizontal piping, top side flat.
   3. Connect branch piping to bottom of mains, except for up-feed risers which shall have take-off out top of main.
   4. Install manual air vents at high points in hydronic piping systems and at coils other than air handling units. Provide 1/4-inch copper, 180-degree bend pipe to discharge vented water into can.
   5. Install automatic air vent on air separator, water coils at air handling units, and where shown. Provide valved inlet and discharge piped to floor drain.
   6. Install drain valves with hose adapters at low points in mains, risers, and branch lines. Drain shall consist of a tee fitting, 3/4-inch ball valve, and short 3/4-inch threaded nipple and cap. Provide drain valves for float type controllers.

F. Fittings: Standard manufactured fittings. Field fabricated fittings and bushings are prohibited on all piping.

G. Unions: Install unions in pipes 2-inch and smaller, adjacent to each valve, at final connections of each piece of equipment and elsewhere to permit alterations and repairs. Install dielectric waterway fittings to join dissimilar metals. Unions are not required on flanged devices.

H. Flanges: Install flanges on valves and equipment having 2-1/2-inch and larger connections.

I. Pipe Ends: Cut pipes, remove burrs and prepare ends with full inside diameter.

J. Joints:
   1. Threaded Joints: Apply Teflon tape to male equipment threads. Do not use pipe with threads which are corroded or damaged.
   2. Soldered Joints: Comply with procedures contained in AWS Soldering Manual-98. Clean surfaces to be joined of oil, grease, rust, and oxides. Clean socket of fitting and end of pipe with emery cloth. After cleaning and before assembly or heating, apply flux to joint surface and spread evenly.

K. Keep openings in piping closed during construction to prevent entrance of foreign matter.

L. Install stainless steel flexible connectors at inlet and discharge connections to base-mounted pumps and other vibration producing equipment.

M. Valves:
   1. Field check valves for packing and lubricant. Replace leaking packing. Service valves with lubricant for smooth and proper operation before placing in service.
   2. Install valves accessible from floor level, located for easy access. Install valves in horizontal piping with stem at or above center of pipe. Install valves in position to allow full stem movement. Provide operating handles for valves and cocks without integral operators.
   3. Provide extended valve stems where insulation is specified.
   4. Provide separate support where necessary.
5. Where soldered end connections are used for valves, use solder having a melting point below 840 degrees F for gate, globe, and check valves; below 421 degrees F for ball valves.
6. Provide valves same size as line size.
7. Provide gate blow-down valves and hose adapters at strainers; same size as strainer blow-off connection.
8. Provide mechanical actuators with chain operators where valves 2-1/2 inches and larger are mounted more than 6 feet above the floor. Extend chains to elevation of 5 feet above floor.
9. Check Valves: Install wafer or lift check valves on pump discharge. Install check valves for proper direction of flow as follows:
   a. Swing Check Valve: Horizontal position with hinge pin level.
   b. Wafer Check Valve: Horizontal or vertical position, between flanges.
   c. Lift Check Valves: With stem upright and plumb.

N. Equipment Piping:
1. Provide combination balancing and shutoff valves to regulate water flow through piping, coils, and at other equipment and piping where shown or required for proportioning flow.
2. Install automatic fill valve in cold water make-up to boilers and chillers. Install three-valve bypass with globe valve around automatic fill valve for quick filling system. Install backflow preventers upstream of fill valve and bypass.

O. Expansion Loops, Guides, and Anchors:
1. Install piping with provisions for expansion and contraction, using expansion loops. Provide for expansion and contraction in mains, risers, and run-outs. Install pipe expansion loops cold-sprung in tension for piping with operating temperatures higher than installed temperature and compression for piping with operating temperatures lower than installed temperatures. Install pipe to absorb 50 percent of total compression or tension produced during anticipated change in temperature. Do not bend piping without use of bending machine.
2. Install guides to properly direct pipe movement into expansion loops and offsets.
3. Install anchors to control movement in piping. Weld anchors to ferrous piping and braze anchors to nonferrous piping. Install pipe anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops.
4. Install in accordance with standards of Expansion Joint Manufacturer's Association, EJMA-93.

P. Drain Pans:
1. Provide drain pans under the entire length of any piping, including valves, joints, and fittings for any liquid-carrying piping system installed over any motor, motor starter, switch gear, transformer, or other electrical equipment. Also, under all such piping located anywhere in any transformer vault, electrical switchboard room, and telephone equipment room. Drain pans shall be not less than 2 inches deep, with a 3/4-inch drain pipe to discharge where shown or to discharge at nearest convenient drain line, floor drain, or other approved drain point.

Q. Expansion Tank and Air Separator Installation:
1. Install tanks as shown; locate appurtenances for easy servicing.
2. Install gate valve and union on air separator drain to facilitate removal of strainer. Route discharge on air separator tank to nearest drain.
3. Check expansion tank after cleaning, testing, and filling of system to ensure system is completely full.
4. Provide bracket supports, saddles, and hangers to support tanks.
5. Install air separator level in both directions, supported from structure so that all pipe can be removed without moving tank.
6. Charge expansion tank with proper air charge.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Test piping systems using ambient temperature water, except where there is risk of damage due to freezing.
B. Release trapped air while filling system using vents at high points. Use drains installed at low points for complete removal of liquid.

C. Isolate equipment and parts that cannot withstand test pressures.

D. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test.

E. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.

F. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

G. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

H. Prepare written report of testing, indicating locations of leaks corrected, method used to correct leaks, number of tests required, and certification that system is leak free.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide 2 hours of instruction on hydronic systems. Include following items as a minimum:
   1. Location of automatic and manual air vents.
   2. Location of strainers and blow down valves.
   3. Location of safety and relief valves.
   4. System drain valves.
   5. System fill and associated devices.
   6. Expansion tank and air separator.
SECTION 23 21 13 - PRE-INSULATED PIPING

PART 1 - GENERAL

1.1 QUALIFICATIONS

A. The system supplier for preinsulated piping systems shall have fabricated systems of the composition defined herein for at least five years.

B. Acceptable Manufacturers:
   1. Perma-Pipe/Ricwil
   2. Thermacor Process Incorporated

PART 2 - PRODUCTS

2.1 PREINSULATED PIPING SYSTEM – CHILLED WATER SUPPLY AND RETURN

A. General Description:
   1. Preinsulated piping systems shall be provided for all underground chilled water piping.
   2. A preinsulated piping system consists of carrier pipe, insulation, protective jacket, connectors, supports, and appropriate fittings.
   3. All underground chilled water pipes with fluid temperatures up to 60 degrees shall utilize polyurethane foam insulation with HDPE jacketing.
   4. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. One square cut, plain end for field cutting and beveling is allowed per straight run of pipe. Other ends shall be factory square cut and factory beveled such that the field welds have the capability of being welded to pass x-ray testing.
   5. Each system layout shall be computer analyzed by the piping system manufacturer to determine stresses, anchor forces, heat losses, and anticipated movements of the service pipe along the entire length of pipe. The conditions for analysis are as follows: installation temperature of 0°F, ambient temperature of 50°F, depth of soil cover is 10 feet, soil conductivity of 10.00 btu-in/sq.ft H-F, and a service line operating temperature of 48°F. Friction between the ground and the jacketing material must be taken into account for the anchor force and stress calculations.
   6. The system design shall be in strict conformance with ASME/ANSI B31.1, latest edition, and stamped by a registered professional engineer.

B. Service Pipe:
   1. Internal piping shall be ASTM A-53, Grade B, ERW carbon steel. Schedule 40 for sizes through 10 inch, 0.375-inch wall thickness for sizes 12 inch and over (standard). Domestically produced pipe is required.
   2. All joints shall be butt-welded for sizes 2-1/2 inches and larger, and socket welded for 2 inches and smaller.
   3. Where possible, straight sections shall be supplied in 35+foot double random lengths with sufficient piping exposed at each end for field joint welding and fabrication.

C. Accessories:
   1. End seals, fittings and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system during shipping, outdoor storage, installation, and operation. End caps on the ends of the service pipe are required to prevent debris from entering the pipe for the period of time up until installation.

D. Insulation:
1. Service pipe insulation (polyurethane foam) for straight sections shall be spray applied or injected such that the final foam product has a nominal 2-3 pound per cubic foot density, 90% minimum closed cell content, conforms to ASTM C-591, and has an initial K factor less than or equal to 0.16. Performed polyurethane foam for fittings is acceptable.

2. To ensure no voids are present, all insulation shall be inspected by one of the following two methods: visually checked prior to application of the protective jacket, infrared inspection of the entire length during the foaming process. After successful completion of testing, all test report documents shall be submitted to the university for records.

3. The insulation shall be applied to the minimum thickness specified below. The insulation thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;14”</td>
<td>1”</td>
</tr>
<tr>
<td>14”+</td>
<td>1-1/2”</td>
</tr>
</tbody>
</table>

E. Protective Jacket:
1. All straight sections of the factory preinsulated piping system shall be jacketed with a High Density Polyethylene jacket conforming to ASTM D1248. PVC jackets shall not be allowed.
2. All HDPE jacketing material shall have minimum wall thickness as specified below. The wall thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Jacket O.D.</th>
<th>Jacket Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.D. &lt; 12”</td>
<td>0.125”</td>
</tr>
<tr>
<td>12”, O.D. &lt; 24”</td>
<td>0.150”</td>
</tr>
<tr>
<td>O.D. &gt;24”</td>
<td>0.175”</td>
</tr>
</tbody>
</table>

3. All fittings of the factory preinsulated piping system shall be jacketed with the same material used for the straight sections of pipe and prefabricated to minimize field joints. Fittings shall be jacketed using a molded HDPE cover over polyurethane foam. Fittings shall be waterproof from the factory without the use of any type of tape, cellophane (or other non-HDPE plastic) wrap, mastic, glue, or hot air welds.

F. Field Joints:
1. All field joints shall be made in straight sections of pipe. Field joints other than at straight sections shall not be acceptable.
2. The method of field joint closure is as follows:
   1) The field joints are pressure tested and inspected for leaks.
   2) A split sleeve with holes in the top is placed around the joint area and secured with straps and sealed to the jacket with tape.
   3) Two-part polyurethane foam is mixed properly and poured into the holes on the top of the split sleeve.
   4) After the foam insulation has expanded and cured, any excess foam shall be removed.
   5) An adhesive backed heat shrinkable sleeve is then placed around the field joint area making sure to overlap the sleeve onto the HDPE jacketing by at least 3” on each side. This 3” overlap is to be completely on the HDPE and does not include the length of overlap of the split sleeve or tape.
   6) Heat is applied using a rosebud torch to the heat shrinkable sleeve slowly and evenly across the length of the sleeve until the sleeve has drawn tight.
   7) Any spots that pucker up during the shrinking process shall be covered with a thick-bodied asphaltic mastic (black roofing compound).
   8) Backfilling of the trench shall not begin until the area has cooled to the touch.

3. The piping systems manufacturer shall furnish all the foam insulation, split sleeves, and heat shrinkable jacketing materials for making the field joints. The contractor shall furnish the straps, tape, knives, saws, torch, gas, and mastic materials.

2.2 PREINSULATED PIPING SYSTEMS – STEAM CONDENSATE RETURN

A. General Description:
1. Preinsulated piping system shall be provided for all underground steam condensate piping.
2. A preinsulated piping system consists of carrier pipe, insulation, protective jacket, connectors, supports, and appropriate fittings.
3. All underground steam condensate return pipes with fluid temperatures up to 200 degrees shall utilize polyurethane foam insulation with HDPE jacketing.
4. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. One square cut, plain end for field cutting and beveling is allowed per straight run of pipe. Other ends shall be factory square cut and factory beveled such that the field welds have the capability of being welded to pass x-ray testing.
5. Each system layout shall be computer analyzed by the piping systems manufacturer to determine stresses, anchor forces, heat losses, and anticipated movements of the service pipe along the entire length of pipe. The conditions for analysis are as follows: installation temperature of 0°F, ambient temperature of 50°F, depth of soil cover is 10 feet, soil conductivity of 10.00 btu-in/sq.ft H-F, and a service line operating temperature of 200°F. Friction between the ground and the jacketing material must be taken into account for the anchor force and stress calculations.
6. The system design shall be in strict conformance with ASME/ANSI B31.1, latest edition, and stamped by a registered professional engineer.

B. Service Pipe:
1. Internal piping shall be ASTM A-53, Grade B, ERW seamless carbon steel. Schedule 80 for sizes through 8 inch, 0.500-inch wall thickness for sizes 10 inches and over (extra strong). Domestically produced pipe is required.
2. All joints shall be butt-welded for sizes 2-1/2 inches and larger, and socket welded for 2 inches and smaller.
3. Where possible, straight sections shall be supplied in 35+ foot double random lengths with sufficient piping exposed at each end for field joint welding and fabrication.

C. Accessories:
1. End seals, fittings and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system during shipping, outdoor storage, installation and operation. End caps on the ends of the service pipe are required to prevent debris from entering the pipe for the period of time up until installation.

D. Insulation:
1. Service pipe insulation (polyurethane foam) for straight sections shall be spray applied or injected such that the final foam product has a nominal 2-3 pound per cubic foot density, 90% minimum closed cell content, conforms to ASTM C-591, and has an initial K factor less than or equal to 0.16. Preformed polyurethane foam for fittings is acceptable.
2. To ensure no voids are present, all insulation shall be inspected by one of the following two methods: visually checked prior to application of the protective jacket, infrared inspection of the entire length during the foaming process. After successful completion of testing, all test report documents shall be submitted to the university for records.
3. The insulation shall be applied to the minimum thickness specified below. The insulation thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 8&quot;</td>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>10&quot;+</td>
<td>2&quot;</td>
</tr>
</tbody>
</table>

E. Protective Jacket:
1. All straight sections of the factory preinsulated piping system shall be jacketed with a High Density Polyethylene jacket conforming to ASTM D1248. PVC jackets shall not be allowed.
2. All HDPE jacketing material shall have minimum wall thickness as specified below. The wall thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Jacket O.D.</th>
<th>Jacket Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.D. &lt; 12&quot;</td>
<td>0.125&quot;</td>
</tr>
</tbody>
</table>
3. All fittings of the factory preinsulated piping system shall be jacketed with the same material used for the straight sections of pipe and prefabricated to minimize field joints. Fittings shall be jacketed using a molded HDPE cover over polyurethane foam. Fittings shall be waterproof from the factory without the use of any type of tape, cellophane (or other non-HDPE plastic) wrap, mastic, glue or hot air welds.

F. Field Joints:
1. All field joints shall be made in straight sections of pipe. Field joints other than at straight sections shall not be acceptable.
2. The method of field joint closure is as follows:
   a. The field joints are pressure tested and inspected for leaks.
   b. A split sleeve with holes in the top is placed around the joint area and secured with straps and sealed to the jacket with tape.
   c. Two-part polyurethane foam is mixed properly and poured into holes on the top of the split sleeve.
   d. After the foam insulation has expanded and cured, any excess foam shall be removed.
   e. An adhesive backed heat shrinkable sleeve is then placed around the field joint area making sure to overlap the sleeve onto the HDPE jacketing by at least 3” on each side. This 3” overlap is to be completely on the HDPE and does not include the length of overlap of the split sleeve of tape.
   f. Heat is applied using a rosebud torch to the heat shrinkable sleeve slowly and evenly across the length of the sleeve until the sleeve has drawn tight.
   g. Any spots that pucker up during the shrinking process shall be covered with a thick-bodied asphaltic mastic (black roofing compound).
   h. Backfilling of the trench shall not begin until the area has cooled to the touch.
3. The piping systems manufacturer shall furnish all the foam insulation, split sleeves, and heat shrinkable jacketing materials for making the field joints. The contractor shall furnish the straps, tape, knives, saws, torch, gas, and mastic materials.

2.3 PREINSULATED PIPING SYSTEMS-STEAM

A. General Description:
1. Preinsulated piping systems shall be provided for all underground steam piping.
2. A preinsulated piping system consists of carrier pipe, carrier pipe insulation, steel casing pipe, casing pipe insulation, HDPE casing pipe insulation protective jacket, connectors, supports, internal moment guides, and appropriate fittings.
3. All underground steam distribution pipes with fluid temperatures up to 355°F shall utilize mineral wool carrier pipe insulation, steel conduit, and polyurethane foam conduit insulation with HDPE jacketing.
4. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. One square cut, plain end for field cutting and beveling is allowed per straight run of pipe. Other ends shall be factory square cut and factory beveled such that the field welds have the capability of being welded to pass x-ray testing.
5. Each system layout shall be computer analyzed by the piping system manufacturer to determine stresses, anchor forces, heat losses, conduit/polyurethane insulation interface temperature, and anticipated movements of the service pipe and conduit along the entire length of pipe. The conditions for analysis are as follows: installation temperature of 0°F, ambient temperature of 50°F, depth of soil cover is 10 feet, soil conductivity of 10.00 btu-in/sq.ft H-F, and a service line operating temperature of 355°F. Friction between the ground and the jacketing material must be taken into account for the anchor force and stress calculations.
6. The system design shall be in strict conformance with ASME/ANSI B31.1, latest edition, and stamped by a registered professional engineer.
B. Service Pipe:
   1. Internal piping shall be ASTM A-53, Grade B, ERW Carbon steel. Schedule 40 for sizes through 10 inch, 0.375-inch wall thickness for sizes 12 inches and over (standard). Coated pipe is not acceptable. Domestically produced pipe is required.
   2. All joints shall be butt-welded for sizes 2-1/2 inches and larger, and socket welded for 2 inches and smaller.
   3. Where possible, straight sections shall be supplied in 35+ foot double random lengths with sufficient piping exposed at each end for field joint welding and fabrication.

C. Subassemblies:
   1. End seals, gland seals, internal moment guides, fittings (tees and elbows), and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system during shipping, outdoor storage, installation, and operation. End caps on the ends of the service pipe are required to prevent debris from entering the pipe for the period of time up until installation.
   2. All subassemblies shall be designed to allow for complete draining and drying of the conduit system.

D. Service Pipe Insulation:
   1. Carrier pipe insulation shall be mineral wool in non-supported sections. Split insulation shall be held in place by stainless steel bands installed on 18 inch centers, or two bands per insulation section, whichever is closest together. The insulation shall have passed the most recent boiling tests and other requirements specified in the Federal Agency Guidelines.
   2. Support/guide sections shall have calcium silicate of the same thickness as the mineral wool with a protective sheet metal sleeve attached to the calcium silicate with screws.
   3. The minimum insulation thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Minimum Insulation Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>2”-4”</td>
<td>1.5”</td>
</tr>
<tr>
<td>6”-10”</td>
<td>2.0”</td>
</tr>
<tr>
<td>12”-14”</td>
<td>2.5”</td>
</tr>
<tr>
<td>16”-20”</td>
<td>3.0”</td>
</tr>
</tbody>
</table>

E. Outer Conduit:
   1. The steel conduit casing shall be a smooth wall, welded steel conduit of the thicknesses specified below:

<table>
<thead>
<tr>
<th>Nominal Conduit Size</th>
<th>Minimum Conduit Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>6”-26”</td>
<td>10 Gauge (0.1345”)</td>
</tr>
<tr>
<td>28”-36”</td>
<td>6 Gauge (0.1943”)</td>
</tr>
<tr>
<td>38”-42”</td>
<td>4 Gauge (0.2242”)</td>
</tr>
</tbody>
</table>

   2. Changes in casing size, as required to allow for carrier pipe expansion into the conduit, shall be accomplished by eccentric and/or concentric fittings and shall provide for continuous drainage of the conduit along the entire length of pipe.

F. Pipe Supports and Guides:
   1. All pipes within the outer casing shall be supported at not more than 10-foot intervals.
   2. The supports shall be designed to allow for continuous airflow and drainage of the conduit.
   3. The carrier pipe supports in straight runs shall be designed to occupy not more than 10% of the annular air space between the carrier pipe insulation and the steel conduit.
   4. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. Support/guide sections shall have calcium silicate of the same thickness as the mineral wool with a protective sheet metal sleeve attached to the calcium silicate with screws. This sleeve shall be as long as the corrugated supports, with a minimum length of 12 inches.
   5. The corrugated metal supports shall be a minimum of 12” long and of sufficient strength (thickness) to support the pipe without the annular air space being encroached upon.
6. Moment guides and rotational arrestors internal to the outer conduit shall be provided on the locations shown on the drawings and additionally where requires by the manufacturer’s analysis.

G. Outer Conduit Insulation:
1. Outer conduit insulation (polyurethane foam) for straight sections shall be spray applied or injected such that the final foam product has a nominal 2-3 pound per cubic foot density. 90% minimum closed cell content, conforms to ASRM C-591, and has an initial K factor less than or equal to 0.16. Preformed polyurethane foam for fittings (elbows and tees) is acceptable.
2. To ensure no voids are present, all insulation shall be inspected by one of the following two methods: visually checked prior to application of the protective jacket, infrared inspection of the entire length during the foaming process. After successful completion of testing, all test report documents shall be submitted to the university for records.
3. The insulation shall be applied to the minimum thickness of 1-1/2 inches. The insulation thickness shall not be less than indicated in these specifications.

H. Protective Jacket
1. All straight sections of the factory preinsulated piping system shall be jacketed with a High Density Polyethylene jacket conforming to ASTM D1248. PVC jackets shall not be allowed.
2. All fittings of the factory preinsulated piping system shall be jacketed with the same material used for the straight sections of pipe and prefabricated to minimize field joints. Fittings shall be jacketed using a molded HDPE cover over polyurethane foam. Fittings shall be waterproof from the factory without the use of any type of tape, cellophane (or other non-HDPE plastic) wrap, mastic, glue, or hot air welds.
3. All HDPE jacketing material shall have minimum wall thickness as specified below. The wall thickness shall not be less than indicated in these specifications.

<table>
<thead>
<tr>
<th>Jacket O.D.</th>
<th>Jacket Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.D.&lt;12”</td>
<td>0.125”</td>
</tr>
<tr>
<td>12”&lt;O.D.&lt;24”</td>
<td>0.150”</td>
</tr>
<tr>
<td>O.D.&gt;24”</td>
<td>0.175”</td>
</tr>
</tbody>
</table>

I. Field Joints
1. All field joints shall be made in straight sections of pipe. Field joints other than at straight sections shall not be acceptable.
2. The method of field joint closure is as follows:
   a. The welds on the carrier pipe field joints are pressure tested and inspected for leaks.
   b. Shipping supports on the ends of the pipe sections are cut off.
   c. Mineral wool insulation (matching the properties of the straight sections) is applied to the joint area and secured in place using stainless steel bands.
   d. A split metal casing is welded to the conduit and each other to form a pressure testable seal around the conduit. This area should allow water to drain freely past the field joint area and not become trapped in a low spot in the conduit.
   e. A split sleeve with holes in the top is placed around the joint area and secured with straps and sealed to the jacket with tape.
   f. Two-part polyurethane foam is mixed properly and poured into the holes on the top of the split sleeve.
   g. After the foam insulation has expanded and cured, any excess foam shall be removed.
   h. An adhesive backed heat shrinkable sleeve is then placed around the field joint area making sure to overlap the sleeve onto the HDPE jacketing by at least 3” on each side. This 3” overlap is to be completely on the HDPE and does not include the length of overlap of the split sleeve or tape.
   i. Heat is applied using a rosebud torch to the heat shrinkable sleeve slowly and evenly across the length of the sleeve until the sleeve has drawn tight.
   j. Any spots that pucker up during the shrinking process shall be covered with a thick-bodied asphaltic mastic (black roofing compound).
k. Backfilling of the trench shall not begin until the area has cooled to the touch.

3. The piping systems manufacturer shall furnish all the mineral wool and foam insulation materials, split metal casing, stainless steel bands, split sleeves, and heat shrinkable jacketing materials for making the field joints. The contractor shall furnish the straps, tape, knives, saws, torch, gas, and mastic materials.

PART 3 - EXECUTION

3.1 PREINSULATED PIPING SYSTEM

A. Installation:
1. Provide the service of a manufacturer’s representative to instruct the contractor on the installation procedures of the piping system and to be present on site to assist during critical stages of installation and testing. The representative must be qualified by the piping system manufacturer who’s responsibility is to provide Field Technical Assistance (FTA).
2. When the manufacturer’s representative is on-site, a report shall be produced consisting of the installation log indicating actually installed conditions, field observations, and pressure test results signed by the manufacturer’s representative, the contractor, and the engineer’s representative. Include documentation by the manufacturer’s representative that the installations in conformance with the manufacturer’s recommendations.
3. A minimum of six inches (6”) of sand or fine gravel bedding shall be placed all around the pipe in the trench. This bedding/fill shall be hand tamped and compacted around the pipes in six-inch (6”) lifts until the fill is six inches (6”) above the top of the jacketing material. The remaining height of the trench shall be evenly and continuously backfilled and compacted in uniform six inch (6”) lifts with suitable clean excavated soil.
4. The field joints shall be installed as described in each product section.

B. Testing – Chilled Water and Condensate Piping
1. The internal pipe shall be hydrostatically tested to 150 psig or 1-1/2 times the operating pressure, whichever is greater. The hydrostatic test pressure shall be held for no less than one hour. In large diameter pipes, pneumatic testing may be an acceptable alternative (at the discretion of the Engineer and the university). Proper safety precautions and coordination must be completes with the university Health and Safety department before testing is initiated.
2. Testing – Welds
   a. Xray first three welds.
   b. If first three pass, X-ray every 10th weld. If failure, xray previous 2 welds after the 10th weld.
   c. After each x-ray failure, x-ray the next three welds.
   d. All welds beyond first three plus every tenth are at no cost to the university.

C. Testing – Steam Piping
1. The service piping shall be hydrostatically tested to 150 PSIG or 1-1/2 times the operating pressure, whichever is greater. The hydrostatic test pressure shall be held for no less than one hour. In large diameter pipes, pneumatic testing may be an acceptable alternative (at the discretion of the Engineer and the university). Proper safety precautions and coordination must be completes with the university Health and Safety department before testing is initiated.
2. Testing – Welds
   a. Xray first three welds.
   b. If first three pass, X-ray every 10th weld. If failure, xray previous 2 welds after the 10th weld.
   c. After each x-ray failure, x-ray the next three welds.
   d. All welds beyond first three plus every tenth are at no cost to the university.

END OF SECTION 23 21 13
SECTION 23 21 16 - PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Strainers:
   1. Place strainers upstream of all regulators, pumps, chillers, boilers, control equipment or any other equipment, which could be damaged or rendered inoperative due to foreign matter in the piping. Provide adequate access for removal.
   2. Provide parallel strainers with isolation valves on primary piping systems where operation is critical and is intended to continue during servicing. Strainers shall then be cleaned through removable caps.
   3. For critical systems, provide pressure gauges to indicate loading. Consider clear see-through duplex strainers or filters for critical applications.
   4. Provide single strainers with isolation valves on secondary piping systems where operation can be interrupted. Provide blowdown valves with caps on single strainers.

B. Hydronic Piping Specialties:
   1. General: Provide factory fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, of if not indicated, provide proper selection as determined by installer to comply with connections, within properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer’s option.

C. General Information - Gauges
   1. Provide gauge cocks at all gauges for removal under operation.
   2. Employ independent gauges with range twice the operating pressure across pumps, strainers, pressure reducing stations, etc.
   3. Monitor all systems by the building automation system for On/Off, temperatures, and pressures.

D. Shall be made in accordance with Section 23 00 00.

1.2 QUALITY ASSURANCE

A. Codes and Standards:
   1. FCI Compliance: Test and rate “Y” type strainers in accordance with FCI 73-1 “Pressure Rating Standard for “Y” Type Strainers”. Test and rate other type strainers in accordance with FCI 78-1 “Pressure Rating Standard for Pipeline Strainers other than “Y Type”.
   2. ASME B31.9 “Building Services Piping” for materials, products, and installation.
   3. Safety valves and pressure vessels shall bear the appropriate ASME label.
   4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Air Vents (manual)
      a. Armstrong Machine Works
      b. Bell & Gossett, ITT; Fluid Handling Div.
d. Spirax Sarco

2. Pipe Escutcheons:
   c. Producers Specialty & Mfg. Corp.

3. Mechanical Sleeve Seal:
   a. Thunderline Corp.

4. Fire and Smoke Barrier Penetration Seal:
   a. Dow Corning
   b. Electrical Products Div./3M
   c. Flame Stop, Inc.

5. Expansion Tanks:
   a. Diaphragm Type Expansion Tanks
      1) Amtrol, Inc.
      2) Watts.
      3) Bell and Gossett ITT; Fluid Handling Div.

6. Air Separators:
   a. Bell and Gossett ITT; Fluid Handling Div.
   b. Amtrol Inc.
   c. Armstrong Pumps, Inc.
   d. Spirax Sarco

7. Combination Pressure and Temperature Relief Valves:
   a. Amtrol, Inc.
   b. Bell and Gossett ITT; Fluid Handling Div.
   c. Watts Regulator Co
   d. Spirax Sarco

8. Low Pressure Strainers:
   a. Metraflex Co.
   b. Hoffman Specialty ITT; Fluid Handling Div.
   c. Watts Regulator Co.
   d. Spirax Sarco

9. Basket Strainers:
   a. R-P&C Valve
   b. Keckley.
   c. Metraflex

10. Pressure Reducing Valves (Water Application):
    a. Amtrol, Inc. Taco, Inc.
    b. Keckley
    c. Armstrong

11. Pump Suction Diffusers:
    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett ITT; Fluid Handling Div.

12. Diverting Fittings:
    a. Armstrong Pumps, Inc.
    b. Bell & Gossett ITT; Fluid Handling Div.
    c. Victaulic Company of America

13. Dielectric Waterway Fittings:
    a. America
    b. Epco Sales, Inc.

14. Hydronic System Safety Relief Valve:
    a. Kunkle Valve Co., Inc.
    b. Watts Regulator Co.
    c. Bell & Gossett ITT; Fluid Handling Div.

15. Pressure Regulating Valves (Steam Application):
a. Spence (preferred)
b. Hoffman Specialty ITT; Fluid Div.
c. Armstrong.

2.2 MATERIALS, GENERAL

A. Air Vents (Manual):
1. Bronze body and nonferrous internal parts; 150 psig working pressure, 212 degree F operating temperature; screwdriver or coin operated type.
2. Float Type: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operation temperature and pressure. With isolating valve.
3. Washer Type: Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.
4. Provide valve or gauge cock for isolation and repair.
5. Pipe high point manual air vents to drain. Notify Project Manager in areas where the manual vents can not be piped to drain.

B. Pipe Escutcheons:
1. General: Provide pipe escutcheons with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Oversized Holes: Provide sheet steel escutcheons, solid or split hinged.

C. Dielectric Protection:
1. General: Provide standard products recommended by manufacturer for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.
2. Use dielectric waterway fittings rather than dielectric unions
3. Installing full-port brass valves, with half-unions at the inlet and outlet, to connect steel to copper pipe is acceptable.
4. Dielectric protection fittings shall be installed in equipment rooms only.

D. Sleeves: Provide pipe sleeves of one of the following:
1. Galvanized sheet steel with lock seam joints for sleeves passing through non-load bearing or non-fire rated walls and partitions. Minimum gauges as follows:
   a. Pipes 2-1/2 inch and smaller: 24 gauge.
   b. Pipes 3 inch to 6 inch: 22 gauge.
   c. Pipes over 6 inch: 20 gauge.
2. Schedule 40 galvanized steel pipe or cast iron pipe for sleeves passing through load bearing walls, concrete beams, fire-rated partitions, foundations, footings, and waterproof floors.
3. Insulated Pipe: Sleeves of sufficient internal diameter to install pipe and insulation and allow for free movement of pipe.
4. In finished areas where pipes are exposed, terminate sleeves flush with wall, partitions, and ceiling and extend 1 inches above finished floors.
5. Fire Protection Lines: Extend sleeves a minimum of 3 inches above finished floor.

E. Mechanical Sleeve Seals:
1. Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation. Foundation walls only.

PIPING SPECIALTIES
F. Fabricated Piping Specialties:
   1. Drip Pans: Fabricated from corrosion resistant sheet metal with watertight joints, and with edges turned up 2-1/2 inch. Reinforce top, either by structural angles or by rolling top over 1/4-inch steel rod. Provide hole, gasket and flange at low point for watertight joint and 1-inch drain line connection.

G. Expansion Tanks:
   1. Compression Tanks: Welded carbon steel rated for 125 psig working pressure, 375 degree F maximum operating temperatures. Provide with taps in bottom of tank for tank fittings and taps in end of tank for gauge glass. Tested and labeled in accordance with ASME Pressure Vessel Code.
      a. Air Control Tank Fittings: Cast iron body, copper-plated tube, brass vent tube plug, and stainless steel ball check.
      b. Tank Drain Fitting: Brass Body, nonferrous internal parts. Fitting to admit air into compression tank drain water, and close off the system.
   2. Diaphragm Type Tanks: Welded steel, rated for 125 psig working pressure, 375 degree maximum operating temperature, flexible diaphragm sealed into tank. Provide taps for pressure gauge, air charging fitting, and drain fitting. Provide with steel legs or saddles. Tested and labeled in accordance with ASME Pressure Vessel Code.

H. Air Separators:
   1. In-line air separators: Cast iron for sizes 1-1/2 inch and smaller, welded steel for sizes 2 inch and larger; tested and labeled for minimum 125 psig working pressure and 350 degree F operating temperature. ASME constructed and labeled
   2. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.

I. Pressure Reducing Valves:
   1. Diaphragm operated, cast iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down and non-corrosive valve seat and stem. Factory set at operating pressure and field adjustable.

J. Hydronic System Safety Relief Valves:
   1. Diaphragm operated, cast iron or brass body, Teflon seat, stainless steel stem and springs, with low inlet pressure check valve, inlet strainer removable without system shut-down, ASME certified and labeled. Select valve to suit actual system pressure and BTU capacity. Set valve to relieve at 10 psi above operating pressure.


L. Dielectric waterway fittings: Threaded end connections installed to isolate dissimilar metals, prevent galvanic action, and prevent corrosion.

M. Automatic Air Vent:
   1. Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240 degree F operating temperature; and having 1/4 inch discharge connection and 1/2 inch inlet connection. B & G Model #87.

N. Pump Suction Diffusers:
   1. Cast iron body, with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger; 175 psig working pressure, 300 degree F maximum operating temperature; and complete with the following features:
      a. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
      b. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
      c. Disposable fine mesh strainer to fit over cylinder strainer.
PIPING SPECIALTIES

d. Permanent magnet located in flow stream, removable for cleaning.

e. Adjustable foot support designed to carry weight of suction piping.

f. Blowdown tapping in bottom; gauge tapping in side.

O. Diverting Fittings: Cast iron body with threaded ends or wrought copper with solder ends; 125 psig working pressure, 250 degree F maximum operating temperature. Indicate flow direction on fitting.

P. Low Pressure Y- Pattern Strainers:

1. Line size strainer with ends matching piping system materials, 125 psig working pressure with Type 304 stainless steel screens with 3/64-inch perforations at 233 per square inch.

   a. Threaded Ends, 2-Inch and Smaller: Cast iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

   b. Threaded or Flanged Ends, 2-1/2-inch and Larger: Cast iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

   c. Butt Welded Ends, 2-1/2-inch and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

   d. Grooved Ends, 2-1/2-inch and Larger: Tee pattern, ductile-iron or malleable-iron body, and access end cap, access coupling with EDPM gasket.

Q. High Pressure Pipeline Strainers:

1. Line size with ends matching piping system materials, 250 psig working pressure with Type 304 stainless steel screens with 3/64-inch perforations at 233 per square inch.

   a. Threaded Ends, 2-Inch and Smaller: Cast iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

   b. Threaded or Flanged Ends, 2-1/2-inch and Larger: Cast iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

   c. Butt Welded Ends, 2-1/2-inch and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

   d. 1/2-inch and Larger: Tee pattern, ductile-iron or malleable-iron body, and access end cap, access coupling with EDPM gasket.

R. Basket Strainers:

1. For 125 psig Systems or less and pipe sizes 16-inches or less: High-tensile ASTM A126B Class B cast iron, angle design, ductile iron clamped cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet.

2. For systems operating greater than 125 psig and pipe sizes greater than 16-inches: High-tensile ASTM A126 Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet.

S. Gas Meter:

1. As per local utility supplier.

2. Coordinate any monitoring of meter with 23 09 00.

T. Domestic Water Meter:

1. General: Install per local utility.

U. Vacuum Breakers

1. Armstrong

2. Watts

3. Hoffman+

4. Spirax Sarco

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
A. General:

1. Install specialties in accordance with manufacturer’s instructions to provide intended performance.
2. Support tanks inside building from building structure in accordance with manufacturer’s instructions.
3. Where large air quantities can accumulate, provide enlarged air collection standpipes.
4. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
5. Provide manual air vents at system high points and as indicated with ¼” X 2” minimum copper tube to direct flow of air and fluid.
6. Provide valved drain and hose connection on strainer blow down connection.
7. Support pump fittings with floor mounted pipe and flange supports.
8. Provide relief valves on pressure tanks, low pressure side or reducing valves, heat exchangers, and expansion tanks.
9. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity.
10. Pipe relief valve outlet to nearest floor drain.
11. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.
12. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration through floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or sleeve but not to insulation with set screws. Install escutcheon to cover penetration hole and flush with adjoining surface. Provide high cap type escutcheon to clear sleeve extension where sleeve extends above finished surface.
14. Mechanical Sleeve Seals: at exterior foundation walls only
   a. Installed between sleeve and pipe.
   b. Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

B. Hydronic Specialties Installation:

1. Install automatic air vents where noted.
2. Install in-line air separators in pump suction lines. Run piping to compression tank with 1/4 inch per foot (2%) upward slope towards tank. Install drain valve on units 2 inch and larger.
3. Install ball valve to isolate expansion tank for cleaning and blowdown. Install drain valve on tank for cleaning/blowdown.
4. Install separator in pump suction lines. Run piping to compression tank with 1/4 inch per foot (2%) upward slope towards tank. Install blowdown piping with ball valve, extend to nearest drain.
5. Provide sufficient number of pipe diameters to inlet of each pump as noted in detail or install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.
6. Install gauge glass and cocks on end of compression tanks. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
7. Provide adequate support from structure to carry twice the weight of the tank, piping connections, fittings, and weight of water assuming a full tank of water. Do not overload building components and structural members. Coordinate concrete inserts with general contractor.

END OF SECTION 23 21 16
PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Pumping System Design
   1. Primary-secondary pumping systems are required where applicable. Provide standby pumps for primary pumps and pumps serving critical areas.
   2. Design pumping systems so that the available positive head at the pump intake will be larger than the required net positive suction head at the highest possible water temperature at the pump intake.
   3. The pump curve representing flow-head relationship shall intersect the system curve at design operating point.
   4. Select pumps to operate at optimum efficiency.
   5. Pump motor shall be non-overloading over the entire pump curve shown by the manufacturer.
   6. Specify pumps with separate pump and motor shafts and replaceable couplings for all but cartridge pumps.
   7. Provide mechanical shaft seals. Gland seals are not acceptable.
   8. Provide duplex pumping units for sewage ejectors and for sump pumps in critical areas. Include lead/lag selector and automatic switchover in the event of failure.
   9. Pumps for Softened or DI water shall have Stainless Steel Impellers

1.2 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. HI Compliance: Design, manufacture and install HVAC pumps in accordance with HI "Hydraulic Institute Standards".
   2. UL Compliance: Design, manufacture and install HVAC pumps in accordance with UL 778 "Motor Operated Water Pumps".
   3. UL and NEMA Compliance: Provide electric motors and components, which are listed and labeled by Underwriters Laboratories, and comply with NEMA standards.
   4. SSPMA Compliance: Test and rate sump and sewage pumps in accordance with Sump and Sewage Pump Manufacturers Association (SSPMA) and provide certified rating seal.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. In-line Circulator Pumps:
      a. Armstrong Pumps, Inc.
      c. Aurora
   2. Vertical In-line Pumps:
      a. Armstrong Pumps, Inc.
      c. Aurora
   3. Base-Mounted End Suction Pumps:
      a. Armstrong Pumps, Inc.
      c. Aurora
   4. Positive Displacement Pumps:
      a. Viking
      b. Blackman
5. Vertical Suspended Sump Pumps and Sewage Ejector:
   a. Armstrong Pumps, Inc
   b. Peerless Pump
   c. Wek Pumps Co.

6. Submersible Sump Pumps and Sewage Ejectors:
   a. Weil
   b. Armstrong Pumps, Inc.
   c. Peerless Pumps

2.2 MATERIALS, GENERAL

A. Provide factory-tested pumps, thoroughly cleaned and painted with one coat of machinery enamel prior to shipment. Type, size and capacity of each pump is listed in the pump schedule. Provide pumps of same type by same manufacturer.

B. In-line Circulator Pumps:
   1. General: Provide All pumps shall be bronze fitted.
   2. Body: Cast iron with suction and discharge gauge tappings.
   5. Seal: Mechanical with carbon seal ring and ceramic seat.
   6. Motor: Non-overloading at any point on pump curve, open, drip-proof, oil lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors.
   8. Impeller: Bronze, enclosed type, hydraulically and dynamically balanced and keyed to shaft.

C. Vertical In-Line Pumps:
   1. General: All pumps shall be bronze fitted.
   2. Body: Cast iron, 125 psi ANSI flanges of equal size, tappings for gauge and drain fittings.
   3. Shaft: Steel with replaceable shaft sleeve.
   4. Seal: Mechanical seal with ceramic seal seat.
   5. Motor: Non-overloading at any point on pump curve, open, drip-proof, ball bearings, 15,000 hours bearing life, with lifting lug on top of motor.
   6. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw.

D. Base Mounted End Suction Pump:
   1. General: All pumps shall be bronze fitted.
   2. Type: Horizontal mount, single-stage, flexible coupling, base mounted, designed for 175 psi working pressure.
   3. Casing: Cast iron, 125 psi ANSI flanges, tappings for gauge and drain connections.
   4. Shaft: Steel with replaceable shaft sleeve.
   5. Bearings: Regreasable ball bearings.
   6. Seal: Mechanical, with carbon seal ring and ceramic seat.
   8. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw.
   10. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.

E. In-Line Recirculation Pumps:
   1. General: Provide in-line recirculation pumps where indicated and of capacities as scheduled.
2. Type: Horizontal, oil lubricated, designed for 125 psi working pressure, 225 degree F (107 degree C) continuous water temperature and specifically designed for quiet operation.
3. Impeller: Bronze.
4. Body: Bronze or stainless steel construction.
5. Shaft: Steel, ground and polished, integral thrust collar.
6. Bearings: Two horizontal sleeve bearings designed to circulate oil.
7. Seal: Mechanical, with carbon seal face rotating against ceramic seat.
8. Motor: Non-overloading at any point on pump curve, open, drip-proof, sleeve bearings, quiet operating, rubber mounted construction, built-in thermal overload protection.

F. Positive Displacement Pump:
1. Type: Single stage, rotary gear.
2. Pumps: Cast iron casing hardened shaft with stainless steel sleeves and mechanical seal, seal-lubricating bronze bearings and integral by-pass type adjustable relief valve.
3. Drive: flexible couplings.
4. Base: Cast iron common mounting for pump and motor with drop rim and drain tapping.

G. Vertical Suspended Sump Pump and Sewage Ejector:
1. General: Provide above pit sump pumps as indicated, of size and capacity as scheduled.
2. Pump: Cast iron shell, stainless steel impeller for sewage ejector; bronze impeller for sump pump, stainless steel shaft, two factory sealed heavy duty grease lubricated sleeve bearings, elevated thrust bearing, ceramic mechanical seal, and perforated steel strainer.
3. Provide extended tubing for grease bearing service above basin cover.
4. Provide basin cover and pump support with access/inspection cover.
5. Provide stainless steel removal system.
6. Controls:
   a. Wall mounted sump/sewage electrical control in a self containing NEMA 12 enclosure, two door type fabricated from not less than 14 gauge steel. Neoprene sponge door gasket seals sufficient to protect interior components from weather and dust. Electrical panel doors constructed from 12 gauge steel with integral latches.
   b. All external operating devices shall be dust and weather proof. Provide operating handle for main power disconnects on the front of the panel. Mount internal components of the enclosures on removable back panels. Mounting screws for components shall not be tapped in the panel enclosure. Internal wiring within and interconnecting between, the panels shall be complete and no field wiring within the panels shall be required. Self contained wiring troughs and cable raceways within the enclosures. External cable traps or wiring troughs are not permitted.
   c. Do not install pressure gauges, pressure switches, water activated devices or water lines of any sort in any electrical control panel. Panel shall include the following:
      1) Low voltage control power transformer
      2) Transformer primary and secondary shall be fused.
      3) Nameplates shall identify the piece of equipment and respective function.
      4) All pilot lights shall be of the push to test type.
      5) Lamps shall be of the filament type and shall include 3-phase calibrated, adjustable class 10 overload relay including ambient compensated thermal overloads. They shall provide differential single-phasing protection.
      6) H.O.A. for each pump.
      7) Make termination of wires and cables at designated terminal blocks only. Identify control wiring as well as terminal blocks by abbreviated legends, clearly designating the equipment with which the wiring and terminal blocks are associated. Identify all wiring with heat shrink labels.
      8) All panel wiring shall be type XHHW, stranded copper. Minimum control wire size shall be #14 AWG.
7. The pump and alarm controller shall provide full range differential control of two pumps, plus a high and low level alarm in response to an electronic, level-proportional signal. Provide automatic switchover in the event one pump fails.

8. The controller will have the capabilities of observing the level and making adjustments of the control form the face of the controller. The level will be displayed on a 40 segment LED bar graph. Level adjustments will be by means of plug-in programming pins.

9. An alarm silence push-button on the face of the controller with four LEDs across the top of the controller shall indicate the ON/OFF state of each pump and alarm control circuits.

10. Locate manual override switch on the face of the unit. This switch will allow the input level signal to be overridden to confirm the performance of the controlled equipment. The switch shall be a spring-return-to-center type with raise-auto-lower positions.

11. The controller shall measure 36 inch high by 45 inch wide by 10 inch deep. All job connections to be a clamp type barrier terminal.

12. One (1) Model A-100 submersible transducer constructed of PVC/Buna N, supported by wall or cover clamps. Transducer will start and stop pumps and give alarm function of high/low level alarm and water in wet well depth. Mercury and/or magnet type float will not be used. Alarm levels and pump start/stop settings will be field adjusted via the plug in programming pin on the control panel.

13. Provide field wiring of pumps, level transducer, moisture temperature sensor, remote alarm, and incoming power.

H. Submersible Sump Pump and Sewage Ejector:

1. General: Provide submersible sewage ejectors and sump pumps as indicated, of size and capacity as scheduled.

2. Pump: Cast iron shell, stainless steel impeller for sewage ejector; bronze impeller for sump pump, stainless steel shaft, two factory sealed heavy duty grease lubricated sleeve bearings, perforated steel strainer and seal to be a carbon rotating against a stationary ceramic seat rated for 225°F.

3. Provide extended tubing for grease bearing service above basin cover.

4. Provide basin cover and pump support with access/inspection cover.

5. Provide stainless steel removal system.

6. Controls:
   a. Wall mounted sump/sewage electrical control in a self containing NEMA 12 enclosure, two door type fabricated from not less than 14 gauge steel. Neoprene sponge door gasket seals sufficient to protect interior components from weather and dust. Electrical panel doors constructed from 12 gauge steel with integral latches.

   b. All external operating devices shall be dust and weather proof. Provide operating handle for main power disconnects on the front of the panel. Mount internal components of the enclosures on removable back panels. Mounting screws for components shall not be tapped in the panel enclosure. Internal wiring within and interconnecting between, the panels shall be complete and no field wiring within the panels shall be required. Self contained wiring troughs and cable raceways within the enclosures. External cable traps or wiring troughs are not permitted.

   c. Do not install pressure gauges, pressure switches, water activated devices or water lines of any sort in any electrical control panel. Panel shall include the following:

      1) Low voltage control power transformer
      2) Transformer primary and secondary shall be fused.
      3) Nameplates shall identify the piece of equipment and respective function.
      4) All pilot lights shall be of the push to test type.
      5) Lamps shall be of the filament type and shall include 3-phase calibrated, adjustable class 10 overload relay including ambient compensated thermal overloads. They shall provide differential single-phasing protection.
      6) H.O.A. for each pump.
      7) Make termination of wires and cables at designated terminal blocks only. Identify control wiring as well as terminal blocks by abbreviated legends, clearly designating the equipment with which the wiring and terminal blocks are associated. Identify all wiring with heat shrink labels.
8) All panel wiring shall be type XHHW, stranded copper. Minimum control wire size shall be #14 AWG.

7. The pump and alarm controller shall provide full range differential control of two pumps, plus a high and low level alarm in response to an electronic, level-proportional signal. Provide automatic switchover in the event one pump fails.

8. The controller will have the capabilities of observing the level and making adjustments of the control form the face of the controller. The level will be displayed on a 40 segment LED bar graph. Level adjustments will be by means of plug-in programming pins.

9. An alarm silence push-button on the face of the controller with four LEDs across the top of the controller shall indicate the ON/OFF state of each pump and alarm control circuits.

10. Locate manual override switch on the face of the unit. This switch will allow the input level signal to be overridden to confirm the performance of the controlled equipment. The switch shall be a spring-return-to-center type with raise-auto-lower positions.

11. The controller shall measure 36 inch high by 45 inch wide by 10 inch deep. All job connections to be a clamp type barrier terminal.

12. One (1) Model A-100 submersible transducer constructed of PVC/Buna N, supported by wall or cover clamps. Transducer will start and stop pumps and give alarm function of high/low level alarm and water in wet well depth. Mercury and/or magnet type float will not be used. Alarm levels and pump start/stop settings will be field adjusted via the plug in programming pin on the control panel.

13. Provide field wiring of pumps, level transducer, moisture temperature sensor, remote alarm, and incoming power.

I. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

PART 3 - EXECUTION

A. Pipe drain from bases and stuffing boxes to floor drains.

B. Discharge increasers shall be concentric and located at pump discharge nozzle. Suction piping reducers shall be eccentric (flat on top) and located at pump suction nozzle. Do not use horizontal elbows at pump suction.

C. Support pumps and piping separately so that piping is not supported by pumps. Provide support under elbows on pump suction and discharge line sizes 4 inches and over.

D. Access: Arrange pumps to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

E. Install base-mounted pumps on minimum of 6 inch high concrete housekeeping pad equal or greater than 3 times total weight of pump and motor with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

F. Install in-line pumps using continuous-thread hanger rod and vibration isolation hangers of sufficient size to support pump weight independent of piping system.

G. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s wiring diagram submittal to electrical installer.

H. Verify that electrical wiring installation is in accordance with manufacturer’s submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

I. Install line size isolation valves on both sides of pumps. The valve on the discharge side shall be a balancing type with “Memory Stop”.

March 1, 2012
J. Install flexible connections on suction and discharge sides of base-mounted pumps between pump casing and valves, unless grooved pipe and fittings are used.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Balance all base-mounted pumps to 1 mil Peak to Peak.

3.3 COMMISSIONING (DEMONSTRATION)

A. Training: Provide 2 hours of instruction to the university representative for each pumping system provided.

END OF SECTION 23 21 23
SECTION 23 22 13 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Steam Supply:
   1. High pressure steam will be supplied to buildings from a central distribution system in accordance with Manual Part 3.4.
   2. Steam Pressure Classifications:
      a. Low pressure steam: 15 psig and under.
      b. Medium pressure steam: 16 psig to 100 psig.
      c. High pressure steam: Above 100 psig.
   3. At each building reduce steam to 15 psig, unless other pressures are required for special equipment.
   4. Design pressure reducing stations with two valves in parallel for two-step control (capus pressure to medium pressure, medium pressure to low pressure) for minimum summer and maximum winter loads. Size valves for 1/3 and 2/3 capacity.
   5. Provide globe valve by-pass for manual control. Size the by-pass valve so that if left unattended in an open position, the steam flow through the by-pass does not exceed the capacity of the safety relief valve selected.
   6. Install air vents in all steam condensate piping high points.
   7. Install drains in all steam condensate low points.

B. Process and Humidification Steam: all secondary steam systems shall utilize clean steam generators supplied by domestic water from ion exchange water softeners.

C. Condensate Return Systems
   1. Condensate return shall be gravity return throughout the building.
   2. Where gravity return is impossible, condensate shall be pumped via pumping traps or steam motivated condensate pumps.

D. Expansion loops are preferred over mechanical expansion devices. Where expansion loops are not practical, provide bellows type expansion devices, not mechanical seal types.

E. Flash Tanks: Do not discharge condensate drip traps above 15 psig into condensate return mains or condensate pump receivers. Design discharge into a flash tank vented into the low pressure side of the system and drip through a low pressure F & T trap to a condensate return main or receiver.

F. Welding process in accordance with Section 23 20 00.

G. Provide remote emergency shut-off valve for auto-claves and similar devices) outside of sterilizer housing. Shutoff to be accessible by user, and labeled “EMERGENCY SHUT-OFF”.

1.2 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the provisions of the following:
   1. ASME B31.9 Building Services Piping for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
   3. UMC Compliance: Fabricate and install steam and condensate piping in accordance with IAPMO “Uniform Mechanical Code.”
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Pressure Reducing Valves:
   a. Spence Engineering Co., Inc. (preferred),
   b. Fisher Controls International, Inc.,
   c. Hoffman Specialty ITT

2. Condensate Return Systems:
   a. Johnson, (preferred)
   b. Armstrong Pumping Station,
   c. Watson McDaniel,

3. Steam Traps; F&T, Inverted Bucket:
   a. Armstrong Machine Works (preferred)
   b. Hoffman Specialty ITT
   c. Spirax Sarco.

4. Steam Traps Radiator Thermostatic Bellows:
   a. Armstrong Machine Works (preferred)
   b. Hoffman Specialty ITT
   c. Spirax Sarco.

5. Steam Relief Valves:
   a. Kunkle Valve Co., Inc., (preferred)
   b. Spence
   c. Watts Regulator Co.

6. Gaskets: Non-asbestos, spiral wound only.
   a. Flexitalic (Preferred)
   b. Garloc

7. Strainers:
   a. Armstrong, (Preferred)
   b. Fisher,
   c. ITT,
   d. Hoffman,
   e. Spirax Sarco.

8. Buried Piping or piping exposed to weather: As specified in Section 23 20 00.

2.2 MATERIALS, GENERAL

A. Steam Piping – in weather protected areas:

1. High and Medium Pressure Steam Piping, (above 15 psig):
   a. Piping 2 Inches and Under:
      1) Pipe: ASTM A53, Grade B, Schedule 40 seamless, black steel, plain ends.
      2) Fittings: Cast iron, Class 300.
      3) Joints: Screwed above ground.
   b. Piping 2-1/2 Inches and Over:
      1) Pipe: Schedule 40 seamless, black steel, beveled ends.
      2) Fittings: Schedule 40, seamless, black steel, butt weld type.
      3) Flanges: 150 lb. forged steel, welded neck or SORF types.

2. Low Pressure Steam Piping (Below 15 psig):
   a. Piping 2 Inches and Under:
      2) Fittings: Screwed, cast-iron, 125 lb.; welded, forged steel socket weld type, 150 lb.
      3) Joints: Screwed, above ground.
   b. Piping 2-1/2 Inches and Over:
      1) Pipe: ASTM A53, Schedule 40, black steel, beveled ends.
      2) Fittings: Schedule 40 steel, butt weld type.
3) Flanges: 150 lb. forged steel, weld neck type.

B. Condensate Piping – in weather protected areas:
1. High and Medium Pressure Steam Condensate, (above 15 psig):
   a. Piping 2 Inches and Under:
      1) Pipe: ASTM A53, Schedule 80 seamless, black steel, threaded or plain ends.
      2) Fittings: Cast iron, threaded, 125 lb.
   b. Piping 2-1/2 Inches and Over:
      2) Fittings: Schedule 80, seamless, black iron, butt weld type.
      3) Flanges: 150 lb. forged steel, welding neck or SORF types

2. Low Pressure Condensate Piping (less than 15 psig):
   a. Piping 2 Inches and Under:
      2) Fittings: Screwed, cast-iron, 125 lb.; welded, forged steel socket weld type, 125 lb.
      3) Joints: Screwed, above ground.
   b. Piping 2-1/2 Inches and Over:
      1) Pipe: ASTM A53, Schedule 80, black steel, beveled ends.
      2) Fittings: Schedule 80 steel, butt weld type.
      3) Flanges: 150 lb. forged steel, weld neck type.

C. Clean Steam Piping:
1. a. Piping 2 Inches and Under:
      1) Pipe: ASTM A53, Schedule 80, Type 316 stainless steel, threaded, and coupled.
      2) Fittings: Screwed, Type 316 stainless steel 125 lb.; welded, forged steel socket weld type, 125 lb.
      3) Joints: Screwed, above ground.
   b. Piping 2-1/2 Inches and Over:
      1) Pipe: ASTM A53, Schedule 80, Type 316 stainless steel, beveled ends.
      2) Fittings: Schedule 80, Type 316 stainless steel butt weld type.
      3) Flanges: 150 lb. Type 316 stainless steel, weld neck type

2. Ball Valves: Full-ported, three-piece valves with threaded connections, type 316 stainless steel body and ball, TFE seats and seals.

D. Clean Condensate Piping
1. Type 316 stainless steel tubing with butt-weld fittings.
2. Ball Valves: Full-ported, three-piece valves with threaded connections, type 316 stainless steel body and ball, TFE seats and seals.

E. Safety Valves:
1. Bronze Safety Valves: Cast-bronze or forged copper body, rated for design pressure, forged copper-alloy disc; fully enclosed, cadmium-plated steel spring - and positive shutoff. Inlet and outlet shall be threaded for valves two inches and below. Larger valves shall be flanged.
2. Cast Iron Safety Valves: Cast-iron body, rated for design pressure; forged copper-alloy disc and nozzle; fully enclosed, cadmium-plated steel spring and positive shutoff; Inlet and outlet shall be threaded for valves two inches and below. Larger valves shall be flanged.
3. Stop-Check Valves Class 125 for 5 psig and below. Class 250 for higher pressures. Threaded bronze swing-checks for 5 psig and below, 2-inch and below pipe diameter. On higher pressure applications use wafer, ball-check, or spring-loaded types per system design

F. Pressure Reducing Valves:
1. Valve Characteristics: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff; cast-iron or bronze body with flanged end connections, hardened stainless-steel trim, and replaceable head and seat. Provide main head stem guide fitted with flushing and pressure-arresting device. Provide dirt cover over pilot diaphragm.
G. Sound Diffractors:
   1. Flanged, cast steel body, rated design pressure.

H. Steam Traps:
   1. Steam Traps: 15 psig and less:
      a. Thermostatic Traps: Cast-brass, angle-pattern body with integral union tailpiece and screw-
         in cap; maximum operating pressure of 25 psig; balanced-pressure, stainless-steel or monel
diaphragm or bellows element and renewable, hardened stainless-steel head and seat. Provide an external Y strainer with blow-down rated for service.
      b. Float and Thermostatic Traps: ASTM A278, Class 30, cast-iron body and bolted cap; renewable,
stainless-steel float mechanism with renewable, hardened stainless-steel head and seat; balanced-pressure, thermostatic air vent made with stainless-steel or monel
diaphragms, and stainless-steel head and seat. Provide an external Y strainer with blow-down rated for service.
      c. Inverted Bucket Traps: ASTM A278, cast-iron body and cap, pressure rated for 25 psig;
stainless-steel head and seat; stainless-steel valve retainer, lever, and guide pin assembly; brass or stainless-steel bucket. Provide an external Y strainer with blow-down rated for service.
   2. Steam Traps: 16 psig to 125 psig:
      a. Thermostatic Traps: Class 125, bronze angle-pattern body with integral union tailpiece and screw-
in cap; balanced-pressure, stainless-steel or monel bellows element and renewable, hardened stainless-steel head and seat. Provide an external Y strainer with blow-down rated for service.
      b. Float and Thermostatic Traps: ASTM A126, cast-iron body and bolted cap; renewable,
stainless-steel float mechanism with renewable, hardened stainless-steel head and seat; maximum operating pressure of 125 psig; balanced-pressure, thermostatic air vent made of stainless-steel or monel bellows, and stainless-steel head and seat. Provide an external Y strainer with blow-down rated for service.
      c. Inverted Bucket Traps: Cast-iron body and cap, pressure rated for 125 psig; stainless-steel
         head and seat; stainless steel valve retainer, lever, and guide pin assembly; brass or
         stainless-steel bucket. Provide an external Y strainer with blow-down rated for service.
      d. Disk Traps: Applications 100 psig and over.

I. Air Vents:
   1. Quick Vents: Cast-iron or brass body, with balanced-pressure, stainless-steel or monel
      thermostatic bellows, and stainless-steel heads and seats.
   2. Float Vents: Cast-iron or brass body, seamless brass float, balanced-pressure, thermostatic
      bellows, and replaceable stainless-steel seat, float, and head.

J. Strainers:
   1. Wye Pattern Strainers: Minimum 125 psig steam working pressure, cast-iron body conforming to
      ASTM A278, Class 30; Grade 18-8 stainless-steel screen, 20 mesh for 2-inch and smaller, and
      manufacturer recommended perforations for 2-1/2 inch and larger; tapped blow-off plug.
   2. Basket Strainers: Minimum 125 psig steam working pressure, cast-iron body conforming to
      ASTM A278-93, Class 30; Grade 18-8 stainless-steel screen, flanged end connections, bolted
      cover.

K. Condensate Cooler:
   1. ASME constructed welded steel for 150 psig working pressure. Steel shell with bronze heads, and
copper tube bundle. Condensate in shell, water in tubes construction. Fabricate with tapping for
vents, low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety
valve, and legs. Provide saddles and support on steel pipe stand.

L. Condensate Movers:
   1. Pumpless condensate system prepiped and skid-mounted:
a. System to include condensate receiver, pumping chamber, all stainless steel, single spring mechanism, inlet and discharge type 304 stainless steel spring loaded check valves, isolation valve, motive steam y-strainer, isolation valves, pressure gauge and site glass assembly.

b. Provide with battery operated cycle counter, motive steam pressure regulating valve and thermostatic air vent.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Piping Installation:
   1. Seal pipe penetrations at building walls, valve pits, etc., with link-seal type mechanical seal with sleeve in concrete to assure watertight penetrations at exterior foundation penetrations.
   2. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
   3. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.
   4. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
   5. Install piping to conserve building space and in such a manner that it will not interfere with use of space, other work or equipment.
   6. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
   7. Provide access panels or doors where valves and fittings are not exposed. Coordinate size and location of access doors as per prints.
   8. Sloping:
      a. Install steam piping at a uniform grade of one inch in 40 feet, in direction of flow. Use eccentric reducers to maintain bottom of pie level.
      b. Install steam condensate piping at a uniform grade of one inch in 40 feet. Install drip trap assembly at low points and before control valves. Run condensate lines from trap to nearest condensate receiver. Provide loop vents over trapped sections.
   9. Where pipe support members are welded to structural building framing; scrape, brush clean, and apply one coat of zinc rich primer to welding.
   10. Install branch connections to supply mains using 45 degree fittings in main with take-off out the top of the main. Use of 90 degree "tee" fittings is permissible, where the use of 45 degree fittings are not practical. Where the length of a branch take-off is less than 10 feet, pitch branch line down toward mains, 1/2 inch per 10 feet.
   11. Install flanges on valves, apparatus and equipment having 2-1/2 inch and larger connections.
   12. Install flexible connectors at inlet and discharge connections to pumps and other vibration producing equipment.
   13. Install strainers on the supply side of each control valve, pressure regulating valve, solenoid valve, traps, and elsewhere as indicated. Install 3/4 inch NPS nipple and ball valve in blow down connection of strainers 2 inch and larger. Use same size nipple and valve as blow-off connection of strainer.
   14. Drip Legs:
      a. Install drip legs at low points and natural drainage points in the system, such as at the ends on mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, pipe bends and expansion joints.
      b. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 200 feet where pipe is pitched down in the direction of steam flow and a maximum of 150 feet where the pipe is pitched up so that condensate flow is opposite of steam flow.
      c. Drip leg diameter: Same diameter as the main up to 4 inch pipe size, 4 inches in diameter for mains up to 8 inches and 1/2 of the diameter on the main thereafter.
d. Drip leg lengths: At least 1-1/2 times the diameter of the main, but never less than 10 inches for systems with supervised warm-up. For systems with automatic warm-up, the drip lengths shall be a minimum of 28 inches in length.
e. Install steam traps close to drip legs.

15. Install unions downstream of valves and at equipment or apparatus connections. Install dielectric unions where joining dissimilar materials.

16. Terminal Equipment Connections:
a. Size pipe for supply and return same size as equipment connections.
b. Install bypass piping with globe valve around control valve. Install only one bypass where multiple parallel control valves are installed.
c. Install vacuum breaker downstream from control valve and bypass, and close to coil inlet connections.
d. Pipe outlet from coils to drip legs and trap.

B. Valves:
1. Install valves with stems upright or horizontal, not inverted. Install valves in position to allow full stem movement. Locate valves for easy access.
2. Provide extended valve stems where insulation is specified.
3. Provide valves same size as line size.
4. Install gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
5. Install globe valves for throttling, bypass, or manual flow control services.
6. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4 inch ball valve, and short 3/4 inch threaded nipple and cap.
7. Install gate valves on drop legs, dirt pockets, and strainer blowdowns to allow removal of dirt and scale

C. Safety Valves:
1. Pipe discharge from safety valves to atmosphere outside the building.
2. Install drip-pan elbow fitting adjacent to safety valve.
3. Pipe drain connection to nearest floor drain.

D. Pressure Reducing Stations:
1. Pressure reducing stations shall have two valves sized for 1/3 and 2/3 capacity of the calculated total steam load. Switch-over between valves shall be via manual gate valves.
2. Each branch of the pressure reducing station shall include a swing-joint to accommodate component removal.
3. Install pressure-reducing valves in accessible location for maintenance and inspection.
4. Install bypass around each reducing valve, with globe valve equal in size to area of reducing valve seat ring.
5. Install gate valves and unions or flanged connection around each reducing valve.
6. Install full size strainer with blow down upstream of each reducing valve.
7. Install 4½-inch pressure gauge, 0 to 200 psi on inlet side and 0 to 60 psi on medium pressure load side of station. Provide anti-siphon loop or “pig-tail” and steam-rated gauge cock. Install pressure gauges where they are clearly visible from the operating level of the reducing station.
8. Control of pressure reducing stations shall have PRVs with pilot positioners and shall fail closed. Pressure reducing station failure shall also have appropriate alarms connected to the Building Automation System.

E. Steam Traps:
1. Install traps at all low points or where condensate is trapped. Install steam traps in accessible locations close to connected equipment and drip legs. Maximum allowable distance from equipment is 4 feet.
2. Install gate valves, strainer, and union upstream from trap; install union, check valve, and gate valve downstream from trap.
3. Applications 15 psig and less:
   a. Thermostatic Traps: Install on convectors and finned-tube radiation.
b. Float and Thermostatic Traps: Install on steam main and riser drip legs, laundry equipment, kitchen equipment, heat exchangers, and coils, or systems with modulated steam supply.

c. Inverted Bucket Traps: Install on steam mains and riser drip legs.

4. Applications 16 psig to 125 psig:

a. Thermostatic Traps: Install on convectors and finned-tube radiation.

b. Inverted Bucket Traps: Install on steam main and riser drip legs, laundry equipment, kitchen equipment, heat exchangers, and coils.

c. Thermodynamic Traps: Install on steam mains, riser drip legs, and heat tracer lines.

F. Flash Tanks:

1. Pitch condensate lines towards flash tank.

2. If more than one condensate line discharges into flash tank, install a swing check valve in each line.

3. Install thermostatic air vent at the top of the tank.

4. Install an inverted bucket or float and thermostatic trap at the low pressure condensate outlet, sized for triple the condensate load.

5. Install a safety relief valve at the tank top.

6. Install a pressure gage, gate valve, and swing check valve on the low pressure (flash) steam outlet.

G. Identification:

1. Label piping, valves, and equipment as specified in Section 23 05 53.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Clean and flush system, with clear water, of all dirt, metal chips, sand, and foreign matter. After flushing, remove, clean, and replace all strainer baskets or screens. Inspect each run of each system for completing of joints, support, accessory items, and obvious leaks.

B. Examine and inspect piping in accordance with ANSI B31.9, Chapter VI.

C. Leak Testing:

1. Provide temporary equipment for testing, including pumps and gages. Test piping system before insulation is installed, wherever feasible, and remove control devices before testing. Subject entire steam supply and return piping systems to leak tests, either as a whole, or in sections; but leave no part untested.

2. Leak test steam supply and return piping systems complying with ANSI B31.9

3. Fill piping systems with clear water, vent all air and pressurize at 150% of design pressure, (but not less than 25 psi) for 2 hours. Test fails if leakage is observed, or pressure drop exceeds 5% of test pressure.

4. Notify Project Manager at least 5 days before performing leak tests.

5. Repair piping systems which fail required piping test, by disassembly and reinstallation, using new materials to the extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics or other temporary repair methods.

6. Drain test water from piping systems after testing and repair work has been completed.

D. Treating: Upon completion, fill, clean, and chemically treat systems. Refer to Section 23 25 00 for chemical treatment of systems.

E. Certification: Prepare written report of testing, indicating locations of leaks corrected, method used to correct leaks, number of tests required, and certification that system is leak free.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide 4 hours of instruction on steam system. Include operation and maintenance and locations of the following as a minimum:
1. Location of traps.
2. Location of strainers and blow down valves.
3. Location of safety and relief valves.
4. System drain valves.
5. System fill and associated devices.

END OF SECTION 23 22 13
PART 1 - GENERAL

1.1 SUMMARY

A. This standard includes flushing, cleaning, and treating the following systems:
1. Flushing, Cleaning, and Treating of water filled systems that interface with the CUP
2. Flushing, Cleaning, and Treating of water filled systems that do not interface with the CUP
3. Steam and condensate systems
4. Pre-cleaning and passivation of condenser water and cooling tower systems

1.2 SYSTEM DESIGN REQUIREMENTS

A. Flushing, Cleaning, and Treating of Systems into the university Distribution System(s).
1. The university Facilities Operations Department personnel are highly motivated to employ the best possible treatment practices to insure the boilers, chillers and associated piping meet or exceed their expected lifespan. The university Central Utility Plant (CUP) personnel co-ordinates the cleaning process for all Chilled Water, Heating Water, Steam, Condensate, Condenser Water, and Cooling Towers.
2. Expansion to the distribution system of the university requires the interface of new piping with the existing piping. With this in mind, the university CUP requires that consistent cleaning and passivation practices are performed throughout the campus on all projects. The goal is for all new facilities are as follows:
   a. Insure that all systems are properly flushed, cleaned, and passivated to minimize foulants returned to the CUP when opened to the existing distribution system.
   b. Insure that the treatment practices employed are compatible with current treatment programs.
   c. Insure that pretreatment practices meet the minimum requirement of the university CUP.
3. Due to the size of the campus chilled water system, creative approaches are being applied to the treated water to manage the inevitable conditions where various contaminants may enter the loop as a result of system expansion. The general goals will be consistent with industry standards for proper treatment of the systems on site. Below is a summary of these standards:
   a. Chilled water mild steel corrosion rates of <0.5 MPY.
   b. Chilled water copper corrosion rates of no greater than 0.1 MPY.
   c. Aerobic biological counts in the chilled water not to exceed 50,000 CFU/ml, sulfate reducing bacteria counts <10 CFUs.
   d. No scale in the chilled water system.
   e. Condensate mild steel corrosion rates of <5.0 MPY.
   f. Condensate copper corrosion rates of <0.1 MPY.
   g. Steam will contain <10 ppb of dissolved oxygen at all times.
4. An equivalent chemical may be used after it has been approved for compatibility by the university CUP. The contractor’s chemical vendor will provide data sheets to the university CUP with the request for approval for an equivalent chemical. Equivalent chemicals cannot be used until they have been approved by the university CUP.
5. It is the contractor’s responsibility to ensure that the system(s) is clean, and has been properly treated. It is the university Water Treatment contractor’s responsibility to verify that the system(s) has been properly treated and is ready to be opened into the university Distribution System(s).
6. Co-ordinate with the university CUP personnel and the current university CUP Water Treatment contractor to determine which tests and inspections will be monitored.
7. Contact the university Outage Coordinator to schedule the opening of any/all system(s) into the same university system(s). The university Outage Coordinator must have all required paperwork on file before they will schedule a system startup.

PART 2 - PRODUCTS (NOT USED)
PART 3 - EXECUTION

A. Chilled Water and Heating Water Systems

1. Chilled water piping must be pre-cleaned and passivated prior to operation. To accomplish this, a method must be provided to circulate these lines at design flow during cleaning. Design minimum flows are stated as a function of pipe diameter in the table below:

<table>
<thead>
<tr>
<th>Pipe diameter in inches</th>
<th>Cross sectional area in feet</th>
<th>Minimum flow GPM for 2 ft/sec velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0.2</td>
<td>180</td>
</tr>
<tr>
<td>8</td>
<td>0.35</td>
<td>314</td>
</tr>
<tr>
<td>12</td>
<td>0.79</td>
<td>708</td>
</tr>
<tr>
<td>16</td>
<td>1.4</td>
<td>1256</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>2818</td>
</tr>
<tr>
<td>36</td>
<td>7.06</td>
<td>6284</td>
</tr>
</tbody>
</table>

2. Taps will be installed, in the vault, on the building side of the supply and return isolation valves. The building pump or temporary circulation pump will circulate the water during the pretreatment process.

3. The addition of Isothiazolin biocide is required. It needs to be added after the system cleaning has been accepted. The nitrite must be added 24 hours after the nitrite has been added.

4. During the flushing, cleaning, and treating process, insure that the minimum flow of 2 feet/second is met. Flows less than 2 feet/second is not acceptable. Flows greater than 2 feet/second, up to the maximum design flow of the system, are acceptable and will assist in the flushing, cleaning, and treating process. Maximum flow is preferred but not required.

5. If possible, on heating water systems, heat the bulk water to 120 degrees F during the circulation period.

6. The university CUP must approve all products that will be used prior to the start of the process. Only factory blended products will be considered. Products blended onsite are not allowed.

7. Biological samples can only be taken Monday through Thursday (Holidays excepted). The sample is sent overnight to the lab. Until the test results return acceptable, a system will not be allowed to be opened into the existing university Distribution system.

8. Two options exist for pre-cleaning. One approach is an alkaline based approach and the other is a nitrite based approach. Consult the university CUP prior to choosing an approach. The alkaline based pre-cleaner applies a minimum of 500 ppm of total inorganic phosphate within the treated water. The pre-cleaner should also contain detergents and dispersants designed to perform an effective cleaning at pH values of 11.5 or higher. The pretreatment plan should also include a minimum of 10 ppm of organic copper corrosion inhibitor such as “TT” in the bulk water. An alternative nitrite based approach uses nitrite, detergents, dispersants and 10 ppm of organic copper corrosion inhibitor such as “TT”. This product is applied to achieve nitrite residuals of in excess of 600 ppm as NO2. These treatment levels can be achieved by adding 2.5 gallons of Nalco-2859, or an equivalent product, to the system per 1000 gallons of system capacity.

   a. Flushing, Cleaning, and treating Chilled Water and Heating Water systems using an Alkaline Based Cleaner. Remember that the timeline below is dependent upon all things occurring as they are written. The time line below is bare bones for an average sized system. Smaller projects may be able to save some time during the filling and draining periods.

   1) Day 1: Fill the entire system that is available with city water and continuously circulate the water with one of the system pumps throughout the building, through all chilled water lines, including lines to vaults. If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run.

   2) Day 2 (24 hours after step #1): The university CUP and/or the university Water Treatment contractor, the contactors water treatment vendor, and the contractor to test the water for conductivity and view the water for clarity. If there are no issues,
the university CUP will give a verbal “OK” to the contractor onsite to proceed with the drain down. This “OK” will be followed up with an e-mail to all interested parties.

3) Day 3: Refill the entire system that is available with city water and add the approved alkaline based cleaner. Your water treatment consultant will need to calculate the correct amount of cleaner needed. Circulate the water with one of the system pumps throughout the building, through all chilled water lines, including lines to vaults. If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run. Run each pump at least two separate times.

4) Day 4: Continue to circulate the entire system with the cleaner in it throughout the building, including lines to vaults (If required). If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run. We would like to see each pump to run two separate times.

5) Day 5 (A minimum of 48 hours after step #3 has been completed): The university CUP and/or the university Water Treatment contractor, the contractors water treatment vendor, and the contractor to test water for pH and conductivity. If the pH test is above 11.5 and the conductivity is elevated well above city water conductivity, a verbal “OK” will be given that the pH of the water is acceptable and the drain down and flushing out of the cleaner can start. This “OK” will be followed up with an e-mail to all interested parties.

6) Day 6: If the following does not occur as written, all dates below this will be affected. When the conductivity is within 10% of the conductivity of the City of Aurora water, contact the university CUP. The university CUP will meet with the contractors water treatment vendor and the contractor at the site and test the water for conductivity and pH. If the conductivity test is within 10% of the conductivity of the City of Aurora water, a verbal “OK” will be given that it is acceptable to add the Isothiazolin biocide. Circulate the system for 24 hours and then proceed to step #7. This “OK” will be followed up with an e-mail to all interested parties.

7) Day 7 (24 hours after step #6 has been completed): Add enough of the approved inhibitor (Nitrite) to raise the level of nitrite in the system to a minimum of 600 ppm. Your water treatment consultant will need to calculate the correct amount of chemical needed.

8) Day 9 (A minimum of 48 hours after step #7 has been completed): Contact the university CUP. The university CUP and/or the university Water Treatment contractor will meet with the contractors water treatment vendor and the contractor at the site and test the water for conductivity and nitrite, and a biological sample will be taken and sent overnight to the lab. If the nitrite is at 600 ppm or higher and the conductivity is elevated, a verbal OK of the nitrite level will be given. If the nitrite level is low, a verbal denial will be given and more nitrite will need to be added. Conductivity will be tested to verify that the conductivity is elevated above city water conductivity. A sample for biological testing will be taken and sent overnight to the university Water Treatment contractors testing lab. We encourage you to have you water treatment consultant to have biological testing performed on the water. Ensure that the lab that performs the testing will test for aerobic, anaerobics and denitrifying bacteria.

9) Keep the system flowing until it is opened up to the university Chilled Water Distribution system.

10) When the test results become available, we will share them with all interested parties. If the sample passes the biological tests, proceed to the next step. If the sample fails one or more of the tests, we will need to met as a group and discuss re-cleaning and re-treating of the system.

11) Once the system has successfully passed all tests, schedule with university Outage Coordinator to open the system up to the university Chilled Water Distribution system.
b. Flushing, Cleaning, and treating Chilled Water and Heating Water systems using a Nitrite Based Cleaner. Remember that the timeline below is dependent upon all things occurring as they are written. The time line below is bare bones for an average sized system. Smaller projects may be able to save some time during the filling and draining periods.

1) Day 1: Fill the entire system that is available with city water and continuously circulate the water with one of the system pumps throughout the building, through all chilled water lines, including lines to vaults. If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run.

2) Day 2 (24 hours after step #1): The university CUP and/or the university Water Treatment contractor, the contactors water treatment vendor, and the contractor to test the water for conductivity and view the water for clarity. If there are no issues, the university CUP will give a verbal “OK” to the contractor onsite to proceed with the drain down. This “OK” will be followed up with an e-mail to all interested parties.

3) Day 3: Refill the entire system that is available with city water and add the approved nitrite based cleaner. Circulate the water with one of the system pumps throughout the building, through all chilled water lines, including lines to vaults. If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run. Run each pump two separate times.

4) Day 4: Continue to circulate the entire system with the cleaner in it throughout the building, including lines to vaults (If required). If there is more than one pump in the system, alternate the pumps at least once during this process to ensure each pump is run. We would like to see each pump to run two separate times.

5) Day 5 (A minimum of 48 hours after step #3 has been completed): The university CUP and/or the university Water Treatment contractor, the contactors water treatment vendor, and the contractor to test water for nitrite and conductivity. If the nitrite test is above 600 ppm and the conductivity is elevated above city water conductivity, a verbal “OK” will be given that the nitrite level in the water is acceptable and the bleed/fill of the nitrite based cleaner can start. With the pump still running, open a ¾” drain to a sanitary sewer and start to purge water from the system. At the same time add water to the system to replace the water that is being purged down the drain. Continue to do this until the nitrite level is down to 200 to 300 ppm. 300 ppm is preferred. DO NOT do this bleed/fill if there is nobody to monitor the process. This “OK” will be followed up with an e-mail to all interested parties.

6) Day 6: If the following does not occur as written, all dates below this will be affected. When the nitrite level in the water is between 200 and 300 ppm, contact the university CUP. The university CUP will meet with the contactors water treatment vendor and the contractor at the site and test the water for conductivity and nitrite. If the nitrite is between 200 to 300 ppm, a verbal “OK” will be given that it is acceptable to add the isothiazolin biocide. Circulate the system for 24 hours and then proceed to step #7. This “OK” will be followed up with an e-mail to all interested parties.

7) Day 7 (24 hours after step #6 has been completed): Add enough of the approved inhibitor (Nitrite) to raise the level of nitrite in the system to a minimum of 600 ppm. Your water treatment consultant will need to calculate the correct amount of chemical needed.

8) Day 9 (A minimum of 48 hours after step #7 has been completed): Contact the university CUP and/or the university Water Treatment contractor. The university CUP will meet with the contactors water treatment vendor and the contractor at the site and test the water for conductivity and nitrite, and a biological sample will be taken and sent overnight to the lab. If the nitrite is at 600 ppm or higher and the conductivity is elevated, a verbal OK of the nitrite level will be given. If the nitrite level is low, a verbal denial will be given and more nitrite will need to be added. Conductivity will be tested to verify that the conductivity is elevated above city...
water conductivity. A sample for biological testing will be taken and sent overnight to the university Water Treatment contractors testing lab. We encourage you to have you water treatment consultant to have biological testing performed on the water. Ensure that the lab that performs the testing will test for aerobic, anaerobic and denitrifying bacteria.

9) Keep the system flowing until it is opened up to the university Chilled Water Distribution system.

10) When the test results become available, we will share them with all interested parties. If the sample passes the biological tests, proceed to the next step. If the sample fails one or more of the tests, we will need to meet as a group and discuss re-cleaning and re-treating of the system.

11) Once the system has successfully passed all tests, schedule with the university Outage Coordinator to open the system up to the university Chilled Water Distribution system.

B. Steam and condensate systems

1. Steam lines do not need to be cleaned or passivated prior to being put in-service since steam is oxygen free, and produces a non-corrosive environment. Steam blows on steam mains that are six inches in diameter or larger are required. A steam blow involves performing a series of cyclic brief venting of steam to atmosphere. The objective is to purge loose particulate material from the steam lines. Remove all strainer screens and check for debris. Clean the screens before reinstalling them. The university CUP Operations staff and/or the university Water Treatment contractor will be present to inspect a limited number of screens. Once this is accomplished the steam line may be put into service.

2. The condensate receivers will need to be initially “dumped” down the drain during the first few days of operation. Add tempering water as need to ensure that the condensate going down the drain is less than 160 F. If possible inspect the receiver for evidence of oil or organic contamination prior to putting the receiver in service. In the unlikely event that oil or organic material has contaminated the condensate receiver contact the CUP for consultation. System cleaning would be required prior to interfacing with the bulk condensate system.

3. Once the conductivity of the condensate is less than 20 and the hardness is 0.5 ppm or less, the condensate can be opened into the university Condensate System.

C. Pre-cleaning and passivation of condenser water and cooling tower systems

1. To perform an effective system cleaning and passivation, a phosphate prep is recommended. The use of N-2578 or an equivalent phosphate based cleaner is suggested to perform the procedure. N-2578 is a blend of inorganic phosphate, detergent, dispersants and organic copper corrosion inhibitors. Sufficient product should be added to the system to boost total inorganic phosphate residuals to a level in excess of 500 ppm as PO4. It is important to maintain good biological control during the passivation process. The use of an oxidizing biocide such as bromine or chlorine is not recommended since it will interfere with the passivation process. The use of a non-oxidizing biocide at a heavy dose is recommended during the passivation.

2. For most effective results, system pH must be maintained in the 7.0-7.5 range, targeting 7.25. The procedure will still work with pH as high as 8.0. If system pH rises to 8.5 the pH should be lowered by gradually adding dilute sulfuric acid. Add acid very slowly and check the pH every 30 minutes. When adding acid, gradually lower the pH into the 7.0-7.5 range, targeting 7.25. If pH goes down to 6.5, gradually add soda ash in a slurry form to raise pH into the 7.0-7.5 range, targeting 7.25.

3. DO NOT OPERATE CHILLERS IN THIS SYSTEM DURING THE CLEANING PROCEDURE.

4. When the PH of the system has been stabilized between 7.0 and 7.5, circulate the treated system at design flows through the entire system for a minimum of 8 hours. Purge all strainers in the system every hour during the pre-cleaning process. After 8 hours of circulation, shutdown the pump(s) and drain the entire system.

5. Fill and flush the entire system with city water until the flush water is clear and free of particulate material. Refill the system with city water. Perform cleaning method as follows:
a. Add a 300 ppm dose of N-2593 biocide or an equivalent to the system while circulating. N-2593 is an isothiazolin based biocide.

b. Gradually add N-2578 to the system. Recommended dose is 2.5 gallons per 1000 gallons of system capacity. Check system pH and insure the concentration is in the range stated above. Contact the university Water Treatment contractor to confirm total inorganic phosphate levels are above 500 ppm.

c. Continue to circulate for 24-48 hours with the system off-line and all legs of the system circulating. Check system pH once every 12 hours. Add anti-foam N-7465 as needed.

d. When the cleaning is complete, drain the system several times until system conductivity is within 200 microsiemens of city water. Contact the university Chemical contractor to confirm total inorganic phosphate levels are below 10 ppm. If the phosphate level remains high, continue to drain and flush. Remove all strainer screens and check for debris. Clean the screens before reinstalling them. The university CUP Operations staff and/or the university Water Treatment contractor will be present to inspect a limited number of screens.

e. The system is now ready for normal operation with a properly run chemical treatment program. It is critical bulk water alkalinity is maintained in the 300-400 ppm range, targeting 350 ppm, in the early phases of operation. If sufficient load is not available to concentrate alkalinity we may artificially boost alkalinity into the recommended range by adding soda ash to the system.

6. Recommended ongoing treatment is using N-23208 phosphonate inhibitor, application of N-2593 isothiazolin based biocide at a 150 ppm dose weekly and the use of N-ST-20 bromine based biocide fed daily.

D. An equivalent chemical may be used after it has been approved for compatibility by the university. The contractor’s chemical vendor will provide data sheets to the university with the request for approval for an equivalent chemical. Equivalent chemicals cannot be used until they have been approved by the university.

END OF SECTION 23 25 01
PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. General Information:
1. Coordinate with the university Facilities Operations for supplies and consulting. New projects should utilize the existing chemical treatment protocols.
2. Coordinate all start-ups with water treatment technician and vendor by notifying the University Project Manager.
3. Chemical treatment sites shall be over concrete dams with a retention volume equal to the volume of the chemical tank. Coordinate with the Architect to provide a curbed area for storage of on-site water treatment chemicals.
4. Separate freeze protection of systems exposed to outside air conditions into those requiring burst protection and those requiring freeze protection.
   a. Snow melt system shall be provided with 40% Dowfrost.
   b. Burst Protection: Systems that have some expansion capability and will remain dormant during the winter and will not require automatic start-up during cold weather shall be protected with concentrations of 35% Dowfrost.
   c. Freeze Protection: Systems that have no expansion capability or will require start-up during cold weather shall be protected with concentrations of 35% Dowfrost.
5. Treatment shall be as automated as possible with controllers and pumps installed in serviceable locations.

B. Hydronic Piping Systems:
1. Equip all closed water systems with a pressure pot feeder. Arrange for shot feeding or for continuous feed as appropriate.
2. Ethylene glycol is prohibited.
3. Provide ion exchange water softener for all boilers and clean steam generators capable of producing a consistent supply of make-up water containing less than 0.5 ppm total hardness. Provide a single softener vessel system for boilers that shut down at least 4 hours per day and a dual vessel system on boilers that run continuously.
4. Provide corrosion coupon racks on all chilled water, heating hot water, and condenser water systems.

C. Closed System: One bypass feeder on each system with isolating and drain valves installed around balancing valve downstream of circulating pumps.

D. Steam System:
1. Bypass feeder on feedwater line to each boiler.
2. Sequestering agent and base pumped from solution tank into boiler, condensate tank, or feedwater line near boiler. Agitator as required.
3. Oxygen scavenger pumped from solution tank into deaerator storage section, feedwater tank or feedwater line as far as possible from boiler. Pumps and agitator as required.
4. Carbon dioxide neutralizer or filming amine pumped from solution tank into steam header. Agitator as required.
5. Solution pumps shall be activated when feedwater pumps are running.
6. Conductivity controller shall sample boiler water on timed cycle and operate solenoid blowdown valve in line to blowdown tank.
7. Liquid level switch in each solution tank shall deactivate solution pump and agitator, and signal alarm.

E. Open System: Provide the system below for small open systems such as humidifiers, air washers, evaporative condensers, liquid coolers or small cooling towers.
1. Two glass-mesh feeder bags per unit, suspended in sump, filled with sequestering agent.
2. Drip feeder feeds sequestering agent into sump. Spray pump interlocked with solenoid valve on drip system.
3. Bleed-off with globe valve piped to drain located above flood line.
4. Conductivity controller samples sump water when activated by pump and operates bleed-off solenoid valve in line to drain.
5. Use automated controllers which start and start pumps to feed corrosion inhibitors, algaeicide, microbicide and biocides.

F. Condenser Water Treatment: Provide the system below for medium to large systems such as cooling towers.
1. Automatic systems for inhibitor, blowdown and biocide, shall be activated by a water meter that is located on the system makeup and by a conductivity controller that has its probes located in condenser water line.
2. Sequestering agent and corrosion inhibitor pumped from solution tank into condenser water supply to tower. Agitator as required.
3. Meter feed biocide with blowdown locked out to ensure biocide retention time.
4. Conductivity controller samples water and operates solenoid bleed valve when condenser water pump is operating.
5. Biocide introduced to tower by continuous feed with solution pump or solenoid valve on tank.
6. Liquid level switch, in each solution tank, deactivates solution pump and agitator, and signals alarm.

G. Provide chemical safety data sheets for inclusion in Operation and Maintenance manuals.

1.2 QUALITY ASSURANCE

A. All services shall be performed by a qualified full-time representative. All products supplied shall meet with all regulations for safe handling and discharge into waste systems.

B. Supplier shall have 24 hour emergency spill response cleanup for any spills resulting from either the filling process or failure of the system. The individuals performing the cleanup must be OSHA certified and shall follow OSHA standards during the spill response process.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Chemical Feeders:
   a. LMI
   b. Pulsafeeder
2. Chemical Treatment Water Meters:
   a. Carlon
   b. LMI
   c. Pulsafeeder
3. Conductivity Meters:
   a. LMI
   b. Pulsafeeder.
4. Pot Feeders:
   a. Neptune, Model FTF-5
5. Glycol Feeder Pressure Switch:
   a. Furnas Electric Company, Model 69WA
6. Deionized Water System:
   a. Culligan
   b. Siemens Water Technologies
c. Continental

7. Deionized Water:
   a. Carbon Filter
      1) Culligan HR-12
   b. Sediment Filter Housing:
      1) Gelman 961062
      2) or approved
   c. Storage Tank:
      1) Raven D9725
   d. Glycerine Filled Gauges:
      1) APAN LSF217
   e. Quality Monitor/Controller:
      1) Thornton 702

8. Glycol
   a. Dow Chemical Company, Dowfrost

2.2 MATERIALS, GENERAL

A. Chemical Feeders:
   1. Positive Displacement Pump: Diaphragm-type metering pump with adjustable flow rate, continuous-duty, fully enclosed electric motor and drive, and built-in relief valve. Construct pump parts in contact with chemical solution of PVC, Teflon, Viton, 316 stainless steel, polyethylene, or other corrosion resistant material.
   2. Chemical Solution Tanks: Chemical-resistant, double walled tanks sized from 60 to 110 gallons to accommodate four treatment products. Inner and outer tanks constructed of polyethylene. Provide tanks with 2 X 2-inch female threaded openings with bung and 1 X 8-inch man way fitting. Tanks shall have no fittings below liquid level. Supply tanks with transfer fittings and level indicator devices.
   3. Packaged Conductivity Controller: Micro-processor based with digital display, acceptance of 4 – 20 mA signal and capable of BACNET communications interface for building automation. Provide with the following control features:
      a. Conductivity control.
      b. ORP control.
      c. Inhibitor feed based on “bleed”, water meter input or percent time.
      d. Chemical time out.
      e. Dual biocide timer.
   4. Cold Water Meter: Positive displacement type with sealed, tamperproof magnetic drive; impulse contact register, single-pole, double-throw, dry-contact switch.
   5. Solenoid Valves: Forged-brass body, globe pattern, general purpose solenoid enclosure, and continuous-duty coil.

B. Pot Feeders:
   1. Bypass type chemical feeder of 5-gallon capacity, steel or cast iron construction, 125 psig working pressure. Provide a filter bag inside the feeder. Provide complete with fill funnel, 2 spare bags, shutoff valve, air release valve, and recirculation shutoff valves on inlet, outlet, and drain valve.

C. Glycol Feeder Assembly:
   1. Assembly shall consist of storage drum, feeder pump, pressure switch and low water cutoff.
   2. Glycol Tanks: Chemical-resistant 50-gallon reservoir fabricated from high density opaque polyethylene with graduated markings; molded fiberglass cover with mounting for liquid level switch, drain connection near bottom of tank.
   3. Pressure Switch: Corrosion resistant and rust proof construction, visible double break contacts which are silver-cadmium oxide, reinforced neoprene diaphragm, no-drift adjustable pressure setting, pilot duty NEMA-A600.
4. Low Water Cut-Off Switch: Switch to stop pump when water level reaches 3 inches (adjustable) above outlet supply fitting in storage drum. Switch shall also light a red warning light at the temperature control panel when activated. Label light "Glycol Storage Low Level".

D. Condenser Water Treatment Control Panel:
1. Control Panel: Solid-state integrated circuits and digital LED displays, in NEMA 250, Type 12 steel enclosure with gasket and lockable door.
2. Control dissolved solids on conductivity and include the following:
   a. LED digital readout display (micro-ohm/cm).
   b. Temperature-compensated sensor probe.
   c. HIGH, LOW, and NORMAL conductance indicator lights.
   d. HIGH or LOW conductance alarm light, trip points field adjustable, with SILENCE switch.
   e. HAND-OFF-AUTOMATIC switch for solenoid bleed valve.
   f. BLEED light to indicate valve operation.
   g. Adjustable internal hysteresis or dead band.
3. Control inhibitor feed on makeup volume and include the following:
   a. Solid-state reset counter (1 to 15, selectable).
   b. Solid-state timer (adjustable 15 seconds to 5 minutes).
   c. Test switch.
   d. HAND-OFF-AUTOMATIC switch for chemical pump.
   e. Illuminated legend shall indicate FEED when pump is activated.
   f. Solid-state lockout timer (adjustable 15 minutes to 3 hours) and indicator light. Lockout timer shall deactivate the pump and activate alarm circuits.
   g. Panel totalizer for amount of makeup.
4. Biocide programmer to include the following:
   a. 24-hour timer with 14-day skip feature
   b. Solid-state bleed lockout timer (0 to 9 hours) and biocide pump timer (0 to 2.5 hours), clock controlled.
   c. Solid state alternator to enable use of two different biocide formulations.
   d. Digital display of time of day (24 hours).
   e. Battery back-up on clock.
   f. HAND-OFF-AUTOMATIC switches for biocide pumps.
   g. BIOCID A and BIOCID B illuminated legends indicate pump running.

E. Condenser Water Filtration Assembly:
1. Filtration unit to remove suspended solids from condenser water.
2. Filter pump shall be all bronze with TEFC motor, strainer, and manual reset motor overload switch with pilot light.
3. Sand filter shall include glass-fiber-reinforced polyester tank, internal distribution piping, differential gage panel, manual and automatic pressure relief valves, backwash valve and sight tube, and graded silica sand.
4. Backwash control shall be automatic including time clocks and/or differential pressure switches, mounted in NEMA 250, Type 4 control panel. Backwash shall use city water versus system water.

F. Chemicals:
1. Chemicals compatible with piping materials, seals, and accessories.
2. Store all chemicals in a secured location on approved containment devices, with all required safety precautions. All chemicals are to be stored in a location that is warm enough to keep the chemical from freezing.
3. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
4. Biocide: Chlorine release agents or microbiocides.
5. Closed System Chemicals: Sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.
6. Steam System Chemicals: Sequestering agent to reduce hardness and prevent feedline congestion, base to provide alkalinity, oxygen scavenger, carbon dioxide neutralizer, and filming amines.
7. Condenser Water (Cooling Tower) System Chemicals: Sequestering agent to inhibit scaling, acid to reduce alkalinity and pH, corrosion inhibitor, and biocide.

8. Open System Chemicals: Sequestering agent to inhibit scaling, acid to reduce alkalinity and pH, corrosion inhibitor, and biocide.

9. Provide quantity of extra chemicals equal to 50% of amount initially installed.

10. Provide “Material Safety Data Sheets” for all chemicals products that are onsite.

G. Glycol:
   1. Dowfrost

H. Chemical Treatment Test Equipment:
   1. Test Cabinet: White enamel with local fluorescent light, capable of accommodating 4 to 10 ml zeroing, titrating burettes and associated reagents.
   2. Test kits shall be provided for determining water hardness and water characteristics. Test kits shall include carrying case and spare reagents. Provide as follows:
      a. Alkalinity titration.
      b. Chloride titration.
      c. Sulfite titration.
      d. Total hardness titration.
      e. Low phosphate.
      f. Conductivity bridge, range 0 to 10,000 micro-ohms.
      g. Creosol red pH slide, complete with reagent.
      h. Portable electronic conductivity meter.
      i. High nitrite.

I. Coupon Racks:
   1. Constructed of 3/4 inch, schedule 80 PVC except schedule 80 mild steel pipe for hot water systems. Size coupon rack to accept four corrosion test specimens. Provide orifice valve in each rack to adjust water flow to 3 to 4 feet/second, throughout the rack.
   2. Install coupon racks in condenser water systems with the warmest water supplying water to the rack.

J. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Chemical Feeders:
   1. Injection point for chemicals shall be higher than top of solution supply tank to prohibit gravity feeding. Interlock conductivity controller with recirculating pump on cooling tower. Install electric solenoid valve in bleed-off line with y-strainer ahead of valve. Chemicals shall be fed into pump discharge line on continuous metered basis.

B. C. Pot Feeders:
   1. Install shot feeders on closed system in upright position with top of funnel not more than 48-inches above floor. Pipe drain, with ball valve, to nearest equipment drain. Install piping adjacent to equipment to allow servicing and maintenance.

C. Glycol Feeders:
   1. After cleaning and flushing piping, refill glycol piping system and glycol tank with mixture of propylene glycol and water solution.
   2. Perform tests to determine the strength of glycol and water solution. Submit written test results to Contracting Officer and include in maintenance manuals. Provide test prior to end of first year of operation and replenish as required.
3. Run full size discharge line from relief valve to storage tank.

3.2 TESTING, CLEANING AND CERTIFICATION

A. General: Ensure system is operational, filled, started, and vented prior to cleaning. Place terminal control valves in open position during cleaning. Add cleaning chemicals as recommended by equipment manufacturer.

B. Heating Water Systems: Hot water heating systems, including converters, pumps, coils and piping shall be cleaned with a solution of trisodium phosphate. This cleaning also applies to glycol systems prior to filling. Apply heat while circulating, slowly raising system to design temperature; maintain for a minimum of 24 hours.

C. Chilled Water Systems:

D. Steam and Condensate Systems:
   1. Steam System: Fill only steam boilers with cleaner and water. Apply heat and maintain for minimum of 12 hours. Cool and drain. Refill with clean water, drain, refill, and check for sludge. Repeat until system is free of sludge. Apply heat to produce steam for piping system and maintain for minimum of 8 hours.
   2. Before placing steam and condensate piping system in service, the piping shall be thoroughly blown out with steam to remove dirt, rust, scale or other contaminants. Blow down to drain or into a container all system strainers once an hour for the first 4 hours and then twice a day until the entire steam and condensate system is interfaced with the university Steam and Condensate systems. Remove all screens and clean them. The university Facilities Operation Representative will witness the inspection and cleaning of an agreed upon number of strainer screens to verify their condition.
   3. Bypass traps and waste condensate until approved by the university Facilities Operations Representative. Following approval by the university Facilities Operations Representative, return condensate to collection system and put traps back in line.

E. All Systems:
   1. When the flushing, cleaning, and treating process is complete, remove all startup screens from the strainer element(s), if installed.

F. Chemical Treatment:
   1. System Start-Up:
      a. The water treatment supplier shall put the treatment equipment into operation, and make adjustments necessary for proper operation.
      b. The water treatment supplier shall provide a written report to the mechanical contractor indicating that all equipment is operating properly.
   2. General: Test hydronic water systems one week after each system start-up and perform a second test one week after the first test. Test for total dissolved solids, inhibitors, and hardness. Provide a certified report after each test indicating initial findings, treatment required and future recommendations. Chemical treatment shall contain no chromates and be bio-degradable. Provide water analysis to determine the type and level of chemicals required for prevention of scale and corrosion.
   3. Provide chemicals and service program for period of three months from project closeout. Vendor must provide “drumless delivery” (transfer of material into customer’s receiver tanks) thereby eliminating any chemical handling on the part of in-house personnel. No drums will be stored on site. Service shall include monthly analysis of water systems. Adjust treatment as needed to maintain system quality as specified. Provide written report of each visit including initial and final water tests, chemicals and amounts used. Provide 24 hour spill response capabilities.
   4. Test Equipment:
a. The water treatment chemical and service supplier shall furnish basic water test equipment, including carrying case and reagents for use with the supplier’s products, include apparatus for determination of treatment residual. Where specialized or supplementary equipment is required, it shall be furnished as part of the offering.

b. Provide test equipment as needed to monitor cycles of concentration and the level of treatment chemicals with the respective systems.

5. Treat raw water available at the project site to sustain the following water characteristics:
   a. Closed System:
      1) Hardness: 0.5 times the make-up water hardness.
      2) Iron: 0.0.
      3) Total Dissolved Solid: 1500 to 2400 ppm (as CaCO3).
      4) Silica: 60 ppm or less.
      5) PH: 9.6 to 10.5
   b. Steam System:
      1) Hardness: 0.0
      2) Iron: 0.0.
      3) Total Alkalinity: 1026 ppm or less.
      4) Silica: 120 ppm or less.
      5) PH 10.5 or above.
   c. Open System:
      1) Hardness: 6 times the make-up water hardness.
      2) Iron: 0.0.
      3) Total Alkalinity: 1026 ppm or less.
      4) Silica: 120 ppm or less.
      5) PH: 7.5 or above.
      6) Total Algae: 0 growth.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide the operating personnel 8 hours of instruction so as to familiarize them with all treatment equipment and procedures. Demonstrate procedure for taking weekly water test on open-loop systems and demonstrate the application and safe handling of supplied chemicals.

B. Provide a written report to the mechanical contractor indicating that operator training has been completed.

END OF SECTION 23 25 13
PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Ductwork:
1. Fiberglass ductwork is not permitted.
2. Designer should evaluate cost effective means to achieve sound alleviation in the ductwork or at the air-handling unit.
3. For larger duct systems, sheet metal cost savings can be realized by specifying different Duct Pressure Classes for the portions of the system that do not experience as much static pressure due to being farther away from the fan. Indicate on drawings the points in the ductwork system where duct construction should change because of change in Duct Pressure Class. Use the SMACNA symbol for “Point of Change in Duct Construction (by the Static Pressure Class).” Be aware of possible static pressure changes in system due to abnormal or emergency conditions.
4. Ductwork used in humidification systems to be stainless steel.
5. All exhaust ductwork used in animal housing areas to be welded stainless steel.
6. All exhaust ductwork in A/BSL-3 applications to be welded stainless steel.
7. Supply air ductwork between fan and terminal boxes (medium and high): Galvanized steel, (Grade G90 or better) shop fabricated rectangular, spiral, round or oval factory fabricated.
8. Rectangular supply air ductwork from discharge or terminal box to air devices (low pressure): Galvanized sheet metal (lined where noted on drawings); factory or shop fabricated.
9. Return air ductwork: Galvanized Steel (lined where noted on drawings): factory or shop fabricated.
10. General building exhaust ductwork: Galvanized sheet metal (lined as noted on drawings); factory or shop fabricated.
11. Transfer Ducts: Internally lined galvanized sheet metal as described above for low-pressure supplies; factory or shop fabricated.
13. Radioisotope exhaust ductwork: 304 stainless steel all welded construction; factory or shop fabricated.
14. Laboratory ductwork: Unlined galvanized or stainless steel ductwork as required by lab service.
15. Duct sizes on drawings shall be outside sheet metal dimensions.
16. Pressure Classifications:
   a. Low Pressure: Three pressure classifications: 1/2 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 2,500 fpm and 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.
   b. Medium Pressure: Three pressure classifications: 3 inch WG positive or negative static pressure and velocity less than 4,000 fpm, 4 inch WG positive static pressure and velocities greater than 2,000 fpm, 6 inch WG positive static pressure and velocities greater than 2,000 fpm.
   c. High Pressure: Positive static pressure over 6 inches WG and less than 10 inches WG and velocities greater than 2,000 fpm.
17. Air Leakage:
   a. Pressure testing of ductwork in the 3-inch and higher Duct Pressure Class is required.
18. Plenums:
   a. Obtain approval from the University Project Manager for the use and arrangement of return air plenums.
   b. Return air grilles for return air plenums shall have sound attenuation boots.

B. Duct Accessories:
1. Volume Control Dampers:
a. Show all required locations for volume control dampers in the ductwork required for air balancing. Main ducts, branch ducts, and zone ducts must have dampers to permit proper division of air quantities. Each supply branch and outlet, and each exhaust branch must have a damper control. Parallel and opposed-blade dampers shall have 4 diameters of straight duct downstream of damper. Avoid locating dampers where it is obvious they won’t be needed because of the inherent pressure drops in the system due to duct layout, longest run, etc.

b. Do not install a volume damper with a frame that protrudes into an airstream due to excessive noise and pressure drop.

c. Provide locking, indicating quadrant regulators on volume control dampers.

d. Dampers that are integral parts of supply or exhaust diffusers or grilles are not permitted for balancing. Provide dampers at branches or takeoffs for balancing.

2. Take-offs:
   a. Provide conical take-offs with a manual damper if warranted. If the main duct is not deep enough for a conical fitting, specify a 45 degree fitting with a round collar.
   b. Do not put manual dampers in take-offs to VAV terminals.

3. Fire and Smoke Dampers:
   a. Provide fire and smoke dampers with a frame style that does not impinge on the duct’s cross-sectional free area to decrease excessive pressure drop and noise.
   b. Provide only “dynamic” rated fire dampers.
   c. Where ventilation ductwork or grills are installed in fire rated walls or partitions install fire/smoke dampers and frames such that its fire resistance shall be equal to that of the wall or ceiling in which it is located. Size dampers to provide full duct size opening through wall, partition, or ceiling.

4. Flexible Duct:
   a. Provide flexible duct to meet the pressure class requirements.
   b. Provide a maximum length of 6 feet.

C. Air Filtration and Cleaning Devices:
   1. Filter all air supplied to the building. Main building ventilation systems shall filter the air at central filter banks. Central filter banks shall have pre-filters
   2. Varicol and HEPA filters shall be accessible for either upstream or downstream servicing. Pleated panel filters shall be removable from the upstream side without disturbing the filters.
   3. Provide manehelic gauges on all air handling unit filter banks.
   4. Exhaust air systems, which have filters for protection of heat recovery coils, shall be 4 inch MERV 7 filters. Filters shall be easily accessible and removable through side access frames.
   5. All filter doors and frames (when applicable) shall utilize closed-coil gasketing.
   6. Provide extended surface high efficiency media filters where the filtering of biological organisms is required.
   7. Provide activated carbon filters where odor control is required.
   8. Provide filters upstream of all coils.

D. Air Terminal Devices:
   1. All air flow dampers need to be far enough away from the heating coil to ensure proper heating of the air at minimum flows.
   2. Design systems to minimize maintenance or service requirements in occupied spaces.
   3. Provide aspirating air outlets to prevent dumping of air into occupied spaces at minimal air volumes.
   4. Design system flexibility to revise zoning with minimal changes in ductwork and controls.
   5. Air terminal units to be used in a healthcare, clean room or lab facility shall have a special VAV unit liner to meet health care facility standards. No exposed fiberglass in the airstream.
   6. The use of fan powered VAV terminals is discouraged. Discuss application of fan powered terminals and other night low limit strategies with the University Project Manager.
   7. Provide manufacturer’s required upstream straight distances before airflow station.
   8. Provide access panels up and downstream of reheat coils.
E.  Building Air Inlets and Outlets:
   1. In buildings where exhaust air may be contaminated, locate the building air supply intake to avoid recirculation of the building exhaust air.
   2. Provide air intake louvers in vertical position with a face velocity and arrangement to mitigate snow intake. Provide 1/2-inch bird screen. Maximum velocity of 500 FPM face velocity.
   3. Locate air intakes as high as possible above grade. Locate bottom of air intakes minimum 20’ above grade.

F.  Diffusers, Registers, Grilles:
   1. Indicate provisions for balancing airflow from outlets or into inlets on the drawings.
   2. Provide for quantities and distribution patterns as shown on the drawings.

1.2 SUBMITTALS
   1. Submit 1/4 inch scaled fabrication and layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that the area materials and rigidity are not reduced.
   2. Submit diffuser, register, and grille performance characteristics including, CFM ratings, pressure drops, NC levels, and throw patterns.
   3. Submit louver color samples for selection and approval.
   4. Submit duct access door coordination drawing for approval.

1.3 QUALITY ASSURANCE

A.  SMACNA Standards:
   1. Comply with SMACNA’s “HVAC Duct Construction Standards, second edition”.
   2. Comply with SMACNA’s “HVAC Air Duct Leakage Test Manual”.


C.  NFPA Compliance: Comply with NFPA 90A “Standard for the installation of Air Conditioning and Ventilating Systems” and NFPA 90B “Standard for the Installation of Warm Air Heating and Air Conditioning Systems”.

D.  Filter media shall be ANSI/UL 900 listed, Class 1 or Class 2, as approved by local authorities.

E.  Air terminals shall comply with ARI 880, “Industry Standard for Air Terminals” and shall bear the ARI certification seal.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A.  Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Flexible Duct:
      a. Flex-Master
      b. Thermaflex
      c. Hercules
   2. Balance Dampers:
      a. Greenheck
      b. Ruskin
      c. Pottorff
   3. Fire Dampers and Combination Fire/Smoke Dampers:
23 30 00 - 4

HVAC AIR DISTRIBUTION

2.2 MATERIALS, GENERAL

A. Ductwork:
   1. Galvanized Ducts: Lock-forming quality, ASTM A527, Coating designation G 90. Provide mill phosphatized finish for exposed surfaces of ducts exposed to view. Provide flat seam construction where standing seams are a hazard to the university operating personnel.
   3. Stainless Steel Ducts: ASTM A480 Type 316 with No. 4 finish on surfaces of ducts exposed to view; Type 304 with No. 1 finish for concealed ducts. Protect finished surfaces with mill applied adhesive protective paper, maintained through fabrication and installation.
   4. Sealant: UL listed, Class 1, flame spread 0, fuel contributed 0, smoke developed 0, water based sealer.
   5. Flexible Duct Fan Connections: Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards. UL 181 fire-resistant, neoprene coated, woven glass fiber fabric, minimum 30 oz. per square yard, crimped into metal edging strip. Suitable for 1-1/2 times duct pressure at connection. Outside flexible duct connectors shall be rated for outdoor use.
      a. Uninsulated: Spiral-wound galvanized steel helix, mechanically locked to fiber glass cloth fabric.
      b. Insulated: Inner core of one ply corrugated aluminum duct, 1-inch thick, ¾ pound insulation and aluminized vapor barrier.
   7. Accessories:
      a. Turning Vanes: Multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades and mounting straps.
      b. Duct Access Doors:
         1) Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.
         2) Fabricate rigid and close fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.
3) Access doors smaller than twelve inches square may be secured with sash locks.
4) Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
5) Access doors with sheet metal screw fasteners are not acceptable.

B. Dampers:
1. Backdraft Dampers: Parallel blades, gravity balanced backdraft dampers shall be made of 16 gauge galvanized steel. Provide center pivoted blades of maximum six inch width, with flexible vinyl sealed edges, linked together in a rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin, and adjustment device to permit setting for varying differential static pressure.
2. Low Pressure Manual Dampers: Single or multi-blade type with position-indicating device and lock.
3. Fire Dampers: Fabricated in accordance with NFPA 90A and UL555. Fabricate curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for low pressure ducts up to 12 inches in height. Fabricate multiple blade fire dampers with 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 X 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops and lock. Fusible links, UL 33, shall separate at 160 degrees F. Provide adjustable link straps for combination fire/balancing dampers
4. Combination Fire Smoke Dampers: Fabricated in accordance with NFPA 90A, 92A, 92B, and UL Standards 555 and 555S. Dampers shall have a UL555 fire rating of
5. Each damper shall be equipped with a heat responsive device which has been tested and approved for use with the damper assembly in accordance with UL555. The heat responsive device shall have a temperature rating of 165 F or 212 F. Dampers shall be UL labeled for use in dynamic systems. The damper shall have a dynamic closure airflow rating equal to or greater than the airflow at the damper's installed location and a dynamic closure pressure rating of 4 in wg.
   a. Dampers shall have a UL555S Leakage rating of Class II and a Temperature rating of 350 F. Dampers shall have a UL555S operational airflow rating equal to or greater than the airflow at its installed location and an operational pressure rating of 4 in wg. Damper actuators shall be factory mounted and qualified for use with the damper in accordance with UL555S. Damper actuators shall be electric type for 120, 24 volt operation or pneumatic type for 20 PSI minimum operation.
   b. The Damper Manufacturer's submittal data shall certify all air performance pressure drop data is licensed in accordance with the AMCA Certified Ratings Program for Test Figures 5.2, 5.3 and 5.5. Damper air performance data shall be developed in accordance with the latest edition of AMCA Standard 500-D.
   c. Damper blades shall be 16 ga galvanized steel 3 Vee type with three longitudinal grooves for reinforcement. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to airflow and operation in either direction through the damper (blades that are non-symmetrical relative to their axle pivot point or utilize blade stops larger than 0.5 in are unacceptable).
   d. Damper frames shall be galvanized steel formed into a structural hat channel shape with reinforced corners. Bearings shall be sintered bronze sleeve type rotating in extruded holes in the damper frame. Jamb seals shall be stainless steel compression type.
6. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

C. Filters:
1. Disposable Pre-filters (MERV 8):
   a. Media: 4 inch thick, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive. 20 gauge galvanized steel holding frame. Nominal size 24 inches by 24 inches. Pre-filters shall have slide-in frames, which shall be sealed to prevent bypass.
b. Rating: 500 FPM face velocity, 0.15 inches w.g. initial resistance, 0.5 inches w.g. final resistance.

2. Extended Surface Retained Media Filters (MERV 11):
   a. Media: Pleated, non-woven cotton fabric, scrim reinforced. 16 gauge galvanized steel holding frame with corrosion resistant coating. Effective media area of 50 square feet per 1000 CFM. Nominal size 24 inches by 24 inches by 12 inches deep.
   b. Rating: ASHRAE 52; 60 percent dust spot efficiency, 96 percent average weight resistance. 500 FPM face velocity, 0.5 inches w.g. initial resistance, 1.2 inches w.g. final resistance.

3. Extended Surface High Efficiency Media Filters (MERV 14):
   a. Media: Pleated, water-resistant glass fiber with aluminum or kraft separators. 16 gauge galvanized steel holding frame with corrosion resistant coating. Effective media area of 50 square feet per 1000 CFM. Nominal size 24 inches by 24 inches by 12 inches deep.
   b. Rating: ASHRAE 52; 95 percent dust spot efficiency. 500 FPM face velocity, 0.65 inches w.g. initial resistance, 1.0 inches w.g. final resistance.

4. High Efficiency Particulate (HEPA) Filters (MERV 17+):
   a. Media: Pleated, water-resistant glass fiber with aluminum separators; ANSI/UL 586. 16 gauge galvanized steel holding frame with corrosion resistant coating. Nominal size 24 inches by 24 inches by 12 inches deep.
   b. Rating: 0.3 micron DOP to 99.97 percent efficiency in accordance with MI-STD-282 thermal DOP penetration test method. 250 FPM face velocity, 1.0 inches w.g. initial resistance, 3.0 inches w.g. final resistance.

5. Activated Carbon Filters:
   a. Assembly: Galvanized steel unit with extruded aluminum tracks to accommodate filter servicing trays in deep V arrangement for upstream/downstream side servicing with disposable panel pre-filter.
   b. Media: Activated carbon density 34 lb./cu ft pelletized or granular to 6 by 10 Tyler mesh screen. Minimum carbon tetrachloride activity of 60 percent. Nominal size 24 inches by 24 inches by 1 inch thick. 9 pounds of carbon per 2000 CRM air flow.
   c. Rating: 500 FPM face velocity, 0.45 inches w.g. initial resistance.

D. Air Terminals:
   1. General: Air terminals shall not exceed sound ratings as scheduled in accordance with AMCA 301 and tested according to AMCA 300.
   2. Single-Duct Variable Air Volume:
      b. Insulation: Minimum 1-inch, 1.5 pound density fiberglass, neoprene or vinyl coated insulation complying with NFPA 90A and UL 181. Exposed edges of insulation coated with NFPA 90A approved sealant.
      c. Air Valve/Damper: Extruded or cast aluminum, automatic pressure compensating. Air valve/damper to seal 100% shut off. Maximum leakage not to exceed 2% of rated airflow at 3 inches inlet static pressure. Valve/Damper to be (normally open)(normally closed). Capable of operating with pressure drop across the unit as low as 0.4 inch w.g.
      d. Airflow Sensor: Multi-point, averaging type.
      e. Heating Coil:Copper tube mechanically bonded to aluminum fins. Leak tested underwater to 200 psig.
      f. Controls: Devices compatible with temperature controls specified in Section 23 09 00.

E. Air Inlets and Outlets:
   1. Louvers:
      a. Test and rate performance in accordance with AMCA 500.
      b. Stationary Steel Louver: 16 gauge galvanized steel louver with 4-inch storm proof and drainable blades on 4-inch centers at 45 degree angle and channel mounted in extruded aluminum rewireable frame. Frame construction with storm proof blades. Provide aluminum bird screen.
c. Stationary Aluminum Louver: Extruded aluminum, 0.081 inch thick louver with 4-inch storm type blades with 5-inch spacing at 45 degree angle with storm proof and drainable blades. Head, sills, and jambs to be one piece extruded structural members. Fastenings shall be either stainless steel or aluminum. Fixed blade accurately fitted and firmly secured to frames. Provide aluminum bird screen mounted in extruded aluminum rewireable frame.

F. Grilles, Registers, and Diffusers:
   1. General:
      a. Test and rate performance in accordance with ARI 880 and ASHRAE 70.
      b. Coordinate borders and mounting frames with ceiling and wall finish.
      c. Provide airflow capacity and throw patterns as shown. Pressure drops of diffusers and supply registers shall not exceed 0.1 inch w.g. and pressure drops for return and exhaust grilles shall not exceed 0.05 inch w.g. unless otherwise shown.
      d. Dampers shall be opposed blade type; key or standard blade screwdriver operated from the face of the unit.
      e. Provide opposed blade damper keys.
   2. Diffusers:
      a. Louvered Face: Square, louvered face steel diffuser with movable blades accessible from face for adjustable discharge and volume damper. Border style compatible with ceiling system. Finish shall be white. Face size shall equal ceiling module size when mounted in ceiling grid; i.e., a diffuser with 24-inch x 24 -inch face would be provided for a 24 x 48 ceiling grid.
      b. Linear bar diffuser with deflection bars fixed and parallel to long dimension with opposed blade damper. Finish shall be white. Provide alignment strips to join sections together end-to-end for continuous appearance.
      c. Slot: Aluminum linear slot diffuser with direction and volume adjustable by 180 degree controller. Number of slots shall be as shown. Finish shall be white. Diffuser shall be capable of being joined end-to-end for continuous appearance. Provide steel blankoffs, alignment pins, end caps, and borders.
      d. Round: Round diffuser constructed of 18 gauge steel with four round cones and round inlet neck. Field adjustable airflow discharge pattern from horizontal to vertical. Finish shall be white. Provide with round steel damper and safety chain.
   3. Registers:
      a. Supply Register: Double deflection, 3/4 -inch blade spacing, 1-1/4-inch steel border with extruded aluminum airfoil blades and steel opposed blade damper. Front blades parallel to long dimension. Blades individually adjustable and securely held in place. Provide gasket between the frame and surface. Register finish shall be white.
   4. Grilles:
      a. Perforated steel ceiling grille with 3/16 -inch diameter holes on 1/4-inch staggered centers. Finish shall be white.
      b. Wall Grilles: 45-degree deflection, 3/4 -inch blade spacing, steel grille with front blades parallel to long dimension. Grille finish shall be white.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL:

A. Accessories
   1. Install access doors of sufficient size at all fire damper, filter, or coil location to provide for cleaning and inspection.
   2. Where fire dampers are installed, paint duct red at damper.
   3. Provide tight fitting access doors sealed with gaskets for inspection and replacement of fusible links. Doors shall be installed, so access is unobstructed. Where these doors occur on concealed ducts, provide access doors in walls or ceiling properly aligned to permit the servicing of the fusible links. Mark ceiling or walls according to accepted identification.
B. Ductwork:
1. Maximum flexible ductwork length shall be 6 feet. Secure flexible ductwork to collars with metal bands. Support at least every 3 feet.
2. General: Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type that will hold ducts true to shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.
3. Construct ductwork to schedule of operating pressures as shown on drawings.
4. Inserts: Install concrete inserts for support of ductwork in coordination with form work, as required to avoid delays in work.
5. Field Fabrication: Complete fabrication of work at project as necessary to match shop fabricated work and accommodate installation requirements.
6. Routing: Run ductwork in shortest route that does not obstruct useable space or lock access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of the building. Limit clearance to 1/2 inch where during is shown for enclosure or concealment of ducts, but allow for insulation thickness. Locate insulated ductwork for 1 inch clearance outside of insulation. In finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings, Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.
7. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.
8. Transitions: Diverging transitions shall not exceed 15 degrees per side. Converging transitions shall not exceed 30 degrees per side.
9. Elbows: Use radius elbows with throat radius equal to duct depth wherever possible.
10. Flexible Duct Fan Connections: Install flexible duct with at least one inch slack to insure that no vibration is transmitted from fan to ductwork.
11. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as the duct. Overlap opening on all four sides by at least 1-1/2 inch. Fasten to duct only.
12. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment controls and other associated work of ductwork system.
13. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at the time of the ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

C. Sealing of Ducts:
1. General:
   a. All ducts, seams, and joints (lateral and horizontal) shall be sealed with sealant.
   b. Metal surfaces to be joined shall be clean, dry, and grease free.
   c. Apply a heavy brush coat of sealant to the interior metal surface of the duct slip joint, then interlock securely the duct sections and position into place.
   d. Apply a heavy brush coat finish of sealant to the exterior metal surface duct joint or seam covering heads of lock joint screws. Ensure that all voids are completely filled to provide a continuous air pressure seal.
   e. Where ducts are subject to excessive vibration or mechanical abuse, the exterior joint finish shall consist of a heavy coat of brush applied sealant reinforced with 2-inch wide glass fabric. Press the reinforcing fabric into the wet sealant and cover with a second coat of brush applied sealant.
2. Low pressure ducts: Seal in accordance with SMACNA standards for Class B seals.
3. Medium and high pressure ducts: Seal in accordance with SMACNA standards for Class A seals.

D. Fire and Smoke Dampers:
1. Install dampers with code approved sleeves.
2. Install in accordance with UL requirements. Provide access door in duct.

E. Grilles, Registers, and Diffuser Installation:
   1. In moist areas, install grilles, registers, and diffusers with stainless steel or aluminum fasteners.
   2. When installing grilles, registers, and diffusers in existing drop ceilings provide additional T-
      sections as required for a finished opening for the grille, register, or diffuser.
   3. All grilles and diffusers mounted in hard ceiling, must be set in frame and be removable to limit
      the use of access doors

F. Air Pressure Gauges:
   1. Provide magnehelic gauges at all air handling unit filter housings.
   2. Provide an engraved nameplate on each magnehelic gauge indicating the normal operating
      pressure.

G. Access Panels:
   1. Install access panels for inspection, maintenance, and cleaning of all automatic dampers, fire and
      smoke dampers, duct turning vanes, before and after all coils, and at other locations where
      equipment will require service.
   2. Access panels to fire dampers shall be labeled with letters not less than 1/2-inch in height reading
      "Fire Damper." For locations where access panels are insulated, provide identifying labels on the
      exterior of the insulation.

H. Filters:
   1. Install bag-in/bag-out filters at location shown on drawings. Housing shall be labeled "Danger,
      Hazardous Material". Install housing in accordance with manufacturer’s instructions and allow a
      minimum 36" clearance for access.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Air Cleaning Devices: Systems shall not be operated during construction.

B. Leakage Tests: Conduct duct leakage test in accordance with SMACNA HVAC Air Duct Leakage Test
   Manual. Repair leaks and repeat tests until total leakage is less than the maximum permissible leakage as
   specified below.

C. General:
   1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.
   2. Ductwork systems in the three-inch W.G. pressure class and higher shall be tested in their entirety
      for leaks. Arbitrary sections of ductwork in the two inch W.G. and lower pressure class shall be
      tested as required by the Engineer.
   3. Test Failures: Duct systems shall be repaired if test pressure and leakage requirements are not met
      or if air noise condition is encountered. Repairs and sealing shall be done with sheet metal, tape,
      sealant, or a combination thereof.

D. Fire and Smoke Damper:
   1. Dampers shall be tested and accepted in accordance with NFPA prior to project closeout.

E. All tests shall be witnessed by the university’s representative and approved by Architect/Engineer and the
   university representative, coordinated through the Project Manager.

END OF SECTION 23 30 00
SECTION 23 40 00 - HVAC FANS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Exhaust Systems:
   1. Exhaust systems that may transport offensive odors, noxious gases, etc., are to be separate
      systems. Provide identifying labels on exterior stacks per the instructions of the Project Manager.
   2. Locate fans so that negative pressure exists in all exhaust ducts within buildings.
   3. Conditioned make-up air shall be provided to compensate for exhaust.
   4. Recirculation systems are not allowed in laboratory spaces.
   5. Refer to Section 23 00 00 for Special HVAC Systems including lab exhaust systems.
   6. Lab exhaust systems to utilize utility set fans, with exhaust stacks. Design of exhaust stack to be
      justified per AHRAE design requirements, or via a wind/wake analysis. Use of high-plume
      dispersion type fans are at the approval of the university project manager.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Fans:
      a. Acme
      b. New York Blower
      c. Greenheck
      d. MK Plastics – Reference 1.1
      e. Cook
      f. Twin Cities

2.2 MATERIALS, GENERAL

A. Centrifugal Fans:
   1. Unit Casing: Galvanized steel panels, formed and reinforced, seams continuously welded. All
      interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Polyester
      Urethane, electrostatically applied and baked. No uncoated metal fan parts will be allowed.
      Provide access doors or panels to allow access to internal parts and components.
   2. Fan Wheel: Non-overloading single width airfoil centrifugal type. Wheels shall be statically and
      dynamically balanced to balance grade G6.3 per ANSI S2.19. Fan wheel shall be manufactured
      with continuously welded steel airfoils and coated with a minimum of 2-4 mils of Polyester
      Urethane, electrostatically applied and baked
   3. Shaft: Turned, ground, polished, and rust protected steel. Designed to operate at no more than 70
      percent of the first critical speed at the top of the fan's speed range.
   4. Shaft Bearings: Air handling quality self-aligning, heavy duty, pillow block type, roller or ball
      type bearings with L.10 rated bearing life of 80,000 operating hours. Provide extended lube lines.
   5. Belt Drives: V-belt drives rated at not less than 200% of motor nameplate rating. Belt speeds shall
      not exceed 4500 feet per minute. Center distances between driver and driven sheaves must meet
      the manufacturer's minimum and maximum. Belts shall be notched AX, BX or CX series.
   6. Sheaves: All sheaves shall be fixed pitch type. Variable pitch sheaves are not permitted. Fixed
      pitched sheaves supplied with units shall be replaceable by fixed pitched sheaves for balancing
      purposes. No sheave shall be less than 3.9 inch PD
   7. All accessible inlet or exhaust openings in fans shall have 1/2 inch square wire mesh guards
      covering those openings as well as belt and pulley guards.
   8. Motor nameplate to include stamped bearing size.
9. All large motors will have double pull, adjustable motor mounts.
10. Size fans to provide design airflow at 15% below maximum rpm as suggested by the manufacturer.
11. Motors: Reference 23 05 13 Motors for more information.
12. Belt Guard: Fabricated to OSHA and SMACNA requirements.
13. Accessories:
   a. Scroll access doors shaped to conform to scroll with quick-opening latches and gaskets.
   b. Galvanized steel companion flanges for duct connections.
   c. 2-inch drain connections.
   d. Removable inlet and outlet safety screens for access to fan for maintenance.

B. Propeller Fans
1. Panel: Painted steel fan panel with welded corners, pre-punched mounting holes, deeply spun venturi, integral stiffening flanges, and motor support.
3. Fan Shaft: Ground, polished, and coated steel.
4. Drive Type:
   a. Belt drive:
      1) Motor Pulleys: Fixed pitch, cast iron, sized for 150 percent of maximum cataloged speed.
      2) Bearings: Heavy duty ball bearings with L10 rated bearing life exceeding 200,000 operating hours.
5. Fan Blades: Statically and dynamically balanced steel or aluminum blades.
6. Accessories:
   a. Rear Fan Guard: Removable or with removable access section for fan maintenance, conforming to OSHA requirements.
   b. Wall Shutter:
      1) Gravity shutter with heavy aluminum frame, blades interconnected with tie-rods, and nylon bearings.
      2) Motorized shutter with heavy aluminum frame, blades interconnected with tie-rods, nylon bearings, and actuator motor to power open and spring return.
   c. Wall Sleeve: Galvanized steel sleeve with moveable angle frame.

C. Roof and Wall Ventilators:
1. Housing: Weatherproof, heavy-gauge spun aluminum with rigid steel internal support structure.
4. Shafts: Solid steel, precision ground, polished, and treated for rust resistance.
5. Drive:
   a. Belt drive:
      1) Bearings: Heavy duty, with L-10 rated bearing-life exceeding 80,000 operating hours.

2.3 QUALITY ASSURANCE

A. Codes, Regulations and Standards: Comply with the following:

B. Propeller Fans
1. Panel: Painted steel fan panel with welded corners, pre-punched mounting holes, deeply spun venturi, integral stiffening flanges, and motor support.
3. Fan Shaft: Ground, polished, and coated steel.
4. Drive Type:
HVAC FANS

a. Belt drive:
   1) Motor Pulleys: Fixed pitch, cast iron, sized for 150 percent of maximum cataloged speed.
   2) Bearings: Heavy duty ball bearings with L10 rated bearing life exceeding 80,000 operating hours.

5. Fan Blades: Statically and dynamically balanced steel or aluminum blades.

6. Accessories:
   a. Rear Fan Guard: Removable or with removable access section for fan maintenance, conforming to OSHA requirements.
   b. Wall Shutter:
      1) Gravity shutter with heavy aluminum frame, blades interconnected with tie-rods, and nylon bearings.
      2) Motorized shutter with heavy aluminum frame, blades interconnected with tie-rods, nylon bearings, and actuator motor to power open and spring return.
   c. Wall Sleeve: Galvanized steel sleeve with moveable angle frame.

7. Motors: Reference 23 05 13 Motors for more information.

C. Roof and Wall Ventilators:
1. Housing: Weatherproof, heavy-gauge spun aluminum with rigid steel internal support structure.
4. Shafts: Solid steel, precision ground, polished, and treated for rust resistance.
5. Drive:
   a. Belt drive:
      1) Bearings: Heavy duty, with L-10 rated bearing-life exceeding 200,000 operating hours.
      2) Pulleys: Cast iron fixed pitch, sized for 150 percent of the driven horsepower.
7. Screen: Aluminum bird screen.
8. Roof Curb:
   a. Field-built.
   b. Prefabricated, galvanized curb with welded seams and fastening flange for “self-flashing”. Closed cell neoprene rubber gasketing around the top of the curb and 1-1/2-inch thick, 3-pound density rigid insulation along the sides. Curbs shall be minimum 14” high.
9. Nameplate: Each fan shall bear a permanently affixed manufacturer’s nameplate containing the model number and individual serial number for future identification.
10. Accessories:
    a. Hinged Sub-base: Rust-proof hinge arrangement permits access to curb well for access to curb mounted dampers.

D. Upblast Roof Ventilators:
1. Housing: Heavy-gauge spun aluminum housing with rigid steel internal support structure, spun aluminum windband, and aluminum base with continuously welded curb cap corners.
3. Motor: Heavy duty type, permanently lubricated, sealed ball bearing, open drip proof, high-efficiency motor, mounted out of the air stream. Reference 23 05 13 Motors for more information.
4. Shafts: Solid steel, turned, ground, and polished.
5. Drive:
   a. Belt drive, cast iron, keyed and securely attached to wheel and motor shafts:
      1) Bearings: Heavy duty, greasable ball type mounted in cast iron housing, L10 rated 100,000 operating hours.
HVAC FANS

2) Pulleys: Fixed pitch, sized for 150 percent of the driven horsepower.


7. Screen: Aluminum bird screen.

8. Roof Curb:
   a. Field-built.
   b. Prefabricated, galvanized curb with welded seams and fastening flange for “self-flashing”.
      Closed cell neoprene rubber gasketing around the top of the curb and 1-1/2-inch thick, 3
      pound-density rigid insulation along the sides.

9. Accessories:
   a. Hinged Sub-base: Rust-proof hinge arrangement permits access to curb well for access to
      curb mounted dampers.
   b. Backdraft damper: Galvanized steel frame, multi-leaf, roll formed aluminum blades with
      nylon bearings. Motorized Actuator.
   c. Provide fans with UL-762 listing for all grease applications.

E. Ceiling Fan:
1. Housing: Acoustically insulated, galvanized steel housing with chatter proof damper.
2. Fan Wheel: Centrifugal type, dynamically balanced.
3. Motor: Permanently lubricated, direct drive motor with built-in overload protection and plug in
   disconnects. Motor mounted on rubber mountings. Reference 23 05 13 Motors for more
   information.

F. Utility Set Fans:
1. General: Fan constructed such that all surfaces are heavy coated high performance epoxy powder
   coating Green Kote TM plus or equal, rated at 250°F, 3-4 mils thick. All nuts, bolts and fasteners
   shall be type 316 SST and powder coated. No un-coated surfaces will be acceptable.
2. Performance: Fan ratings shall be based on tests made in accordance with AMCA Standard 210
   and licensed to bear the AMCA Certified Ratings Seal for Air Performance. Fans shall have a
   sharply rising pressure characteristic extending throughout the operating range to assure quiet and
   stable operation. Fan brake horsepower shall be equal to or less than the BHP specified in the
   schedule at the listed static pressure and CFM.
3. Sound: Fan manufacturers shall provide sound power level ratings for fans tested and rated in
   accordance with AMCA Standards 300 and 301.
4. Bearings: Bearings are to be grease lubricated, precision anti-friction ball, self-aligning, pillow
   block design. Bearings shall be designed for a minimum L-10 life of 200,000 hours when rated at
   the fan’s maximum cataloged operating speed. Fan bearings shall be visible and accessible for
   inspection, maintenance, and replacement. Bearings enclosed within the fan housing where they
   can be exposed to the corrosive gas steam are not acceptable.
5. Construction: Fan constructed in accordance with the ASTM D-4167 standard for fiber-reinforced
   plastic fans and blowers to ensure structural integrity. Fans shall be suitable for outdoor use.
6. Housing: Constructed with fire retardant vinyl ester resin with an ASTM E84. Housing laminate
   construction shall conform to ASTM Standard C-582. Shaft hole openings fitted with a teflon
   closure having a maximum clearance of 1/32 inch to minimize leakage. Inlet assembly bolted to
   permit wheel removal. Housing shall have weep holes to allow moisture to drain.
7. Wheel: Backward inclined, non-overloading design for increased efficiency. Wheel coated with a
   fire-retardant vinyl ester resin with an ASTM E84 flame spread of 25 or less. Wheel hub
   permanently bonded to the shaft and completely encapsulated in FRP to insure corrosion resistant
   integrity.
8. Shaft: Solid, ASTM A-108 steel, grade 1040/1045 with an FRP sleeve fixed securely and bonded
   to the wheel backplate. The sleeve shall extend out through the housing shaft hole for corrosion
   protection. Shaft shall be countersunk for tachometer readings.
9. Fan shaft and bearings to be eccentric lock or taper lock to prevent fretting. Set screws for bearing
   locks are not allowed.
10. Balance and Run test: The wheel and shaft shall be dynamically balanced, as an assembly, in
    accordance with ASTM D-4167 and ANSI S2.19-1975, Grade 6.3. Prior to shipment, completed
    fans shall receive a final test-balance at the specified operating speed.
11. Accessories:
   a. Weather Cover/Belt Guard.
   b. V-Belt Drive, Adjustable. Provide multi-belt type drive.

12. Provide spring-operated automatic lubricator. Provide LubeSite 560 with 6 oz reservoir. Each lubricator shall be suitable for outdoor use, corrosion resistant, suitable for operation from –20 to 120º F, with Viton piston seal ring, and fully compatible with fans and lithium-based lubricant. Other acceptable manufacturers: Alemite, or SKF.

END OF SECTION 23 40 00
SECTION 23 52 00 - HEAT BOILERS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Boilers included in this Section are intended for structures constructed outside the practical limits of the campus central steam distribution system and have access to natural gas.

B. Design these systems as simple heating water hydronic systems to meet building heating and ventilating requirements.

1.2 QUALITY ASSURANCE

A. Electrical components shall comply with NFPA 70-96 and be UL listed.

B. Boilers shall comply with ASME Boiler and Pressure Vessel Code, Section IV-95.

C. Boilers tested and rated according to the Hydronics Institute’s “Testing and Rating Standard for Heating Boilers” with I=B=R emblem on a nameplate.

1.3 WARRANTY

A. Boilers warranties shall be provided in accordance with Section 23 00 00, including the manufacturer’s standard warranty of not less than 10 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Inclined Water Tube Boiler:
   a. Anax
   b. Rite

2. Cast-Iron Boilers:
   a. Burnham
   b. Peerless
   c. Weil-McLain

3. High-Efficiency Compact Boiler:
   a. Lochnnar
   b. Patterson-Kelly

4. Scotch Marine Boiler:
   a. Burnham
   b. Kewaner
   c. Superior

5. Condensing Boiler:
   a. AERCO
   b. Buderus
   c. Viessman

2.2 MATERIALS, GENERAL

A. Inclined Water Tube Boiler:
1. **Type:** Factory assembled, packaged, and tested forced draft inclined water tube boiler. Non-condensing design to operate at 80 percent efficiency.

2. **Construction:**
   a. Free-floating tube bundle assembly consisting of steel tubes, 2-inch diameter supported by steel frame with expansion joint at each corner.
   b. Tubes sloped upward from rear to front to eliminate air bubbles.
   c. Full-face reinforced neoprene head gasket.
   d. 18 gauge galvanized or painted steel jacket.

3. **Pressure Rating:** 125 psi working pressure, ASME stamped.

4. **Burner:**
   a. UL listed forced draft burner for operation with pressurized vent stack without barometric damper or induced draft fan.
   b. Fuel: Natural gas.
   c. Electronic supervised spark ignition.
   d. **Burner Safety Controls:**
      1) Scanner or ultraviolet flame detector.
      2) Airflow switch.
   e. Positive pressure at flue collar.

5. **Boiler Controls and Trim:**
   a. Operating control.
   b. High limit control
   c. Low water cutoff.
   d. ASME pressure relief valve set at proper psi for operating conditions.
   e. Combination temperature/pressure gauge.
   f. Built-in air elimination.
   g. Control panel with indicating lights.

6. **Gas Train:**
   a. UL and FM listed gas train, factory assembled.
   b. Main gas pressure regulator.
   c. Main gas valve.
   d. Main and pilot gas shut-off valves.
   e. Auxiliary gas valve.
   f. Dual safety gas valves.
   g. Low and high gas pressure gas switches above 2500 MBH.

B. **Cast-Iron Boilers:**

1. Factory assembled and packaged, with cast-iron sections set on an insulated steel base, sealed with high-temperature sealant, held together with tie rods, and with insulated extended jacket and vent connection.

2. **Gas Burner:**
   a. Atmospheric or forced draft type.
   b. Modulation firing.
   c. Prepurge.
   d. Low fire start.
   e. Modulating position air control.
   f. Pressure regulator.
   g. Gas valves, manual shutoff, intermittent spark or glow coil ignition, flame-sensing device, and automatic 100 percent shutoff.

3. **Pressure Rating:** 30 psig.

4. **Fuel:** Natural gas.

5. **Trim and Accessories:**
   a. Safety Relief Valve: ASME rated, factory set at boiler pressure rating.
   b. Gauge: Combination water pressure and temperature. Pressure range to be 0 - 50 psig and temperature range to be 40 to 240 degrees F.
   c. Low Water Cutoff: Prevent burner operation on low water level.
d. High Limits: Two temperature controls to limit boiler water temperature. One with automatic reset, the other with manual reset.

e. Operating Controls: Prewired, factory assembled electric control including pilot safety and thermocouple transformer, 24-volt gas valve, manual main and pilot valves.

f. High pressure gas switches
g. Electronic pilot ignition.
h. Safety pilot switches: 100% shut-off.
i. Gas pressure regulator.
j. Safety Controls: Energize ignition, limit time for establishing flame, prevent opening of gas valve until pilot flame is proven, and stop gas flow on ignition failure.

C. High-Efficiency Compact Boiler:
1. Radial fired, vertical hot water boiler with gas fired power burner. Non-condensing design to operate at AGA certified efficiency of 85 percent.

2. Construction:
   a. Combustion Chamber: 16 gauge corrosion resistant aluminized steel or cast iron.
   b. Heating Surface: Finned copper tubes.
   c. Outer Cabinet: Minimum 16 gauge steel, air tight, with an insulating air space between the combustion chamber and outer cabinet.
   d. Cabinet Finish: Baked epoxy coating finished inside and out.
   e. Factory assembled and fire tested.


4. Burner:
   a. Gas power burner, radial fired.
   b. Fuel-air mixture controlled by multiple brass orifices and venturi core equipped to measure air flow rate to the burner.

5. Burner Controls:
   a. Electric spark ignition with interrupted type pilot.
   b. Flame rod pilot and main flame control.
   c. AGA approved electronic flame safeguard programmer with pilot failure and lock-out with manual reset.

6. Gas Manifold:
   a. AGA lubricated plug cock.
   b. Pressure regulator.
   c. Low gas pressure switch.
   d. Two solenoid-operated diaphragm valves.
   e. Pilot gas manifold with cock, pressure regulator, gas filter and solenoid valve.
   f. Both gas manifolds, main and pilot, to be accessible without removing cabinet.

7. Smoke Venting:
   a. Boiler AGA certified as “Category 1” for venting, requiring either a double wall or an insulated type “B” vent pipe.

8. Trim and Accessories:
   a. Safety Relief Valve: ASME rated, factory set at boiler pressure rating.
   b. Gauge: Combination water pressure and temperature. Pressure range to be 0 to 50 psig and temperature range to be 40 to 240 degrees F.
   c. Low Water Cutoff: Prevent burner operation on low water level.
   d. High Limits: Two temperature controls to limit boiler water temperature. One with automatic reset, the other with manual reset.


D. Scotch Marine:
1. Multi-pass, horizontal fire-tube boiler factory-mounted on heavy steel base frame. Boiler to provide 80 percent efficiency.

2. Construction:
   a. Insulated metal jacket.
   b. Insulated front flue doors.
c. Refractory filled rear access with observation port.
d. Bottom blowdown connection.
e. Heating Surface: 5 square feet of heating surface per rated BHP.
f. Cabinet Finish: Baked epoxy coating finished inside and out.
g. Factory assembled and fire tested.

3. Burner:
a. UL/FM approved forced-draft burner, rated to produce full output at 5200-foot elevation.
b. Radial port flame retention type burner head and diffusers.

4. Burner Controls:
a. Direct spark ignition electrode.
b. Ultraviolet flame detector.
c. Airflow safety switch.
d. Modulating control motor with linkage to control modulating gas valve and air inlet damper for proper fuel air mixtures.

5. Gas Train:
a. AGA lubricated plug cock.
b. Gas regulator.
c. Motorized gas valve with proof of closure switch.
d. Safety gas valve.
e. Pressure regulator.
f. High and low gas pressure switch.
g. Pilot solenoid valve.
h. Pilot gas manifold with cock, and pressure regulator.
i. Both gas manifolds, main and pilot, to be accessible without removing cabinet.

6. Smoke Venting:
a. Boiler AGA certified as “Category 1” for venting, requiring either a double wall or an insulated type “B” vent pipe.
b. Type B Gas Vent: Double wall gas vent complying with NFPA 211-96, inner pipe of sheet aluminum, outer pipe of galvanized steel sheet. Provide tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire-stop spacers, and fasteners.

7. Trim and Accessories:
a. Safety Relief Valve: ASME rated, factory set at boiler pressure rating.
b. Gauge: Combination water pressure and temperature. Pressure range to be 0 to 50-psig and temperature range to be 40 to 240 degrees F.
c. Low Water Cutoff: Prevent burner operation on low water level.
d. High Limits: Two temperature controls to limit boiler water temperature. One with automatic reset, the other with manual reset.


E. Condensing Boiler:
1. Boilers shall be natural gas fired, condensing fire-tube design with a modulating forced draft power burner and positive pressure vent discharge.
a. Modulating Air/Fuel Valve and Burner
b. The boiler burner shall be capable of a 10 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves.
c. The burner shall produce <30 ppm of NOx corrected to 3% excess oxygen.
d. All burner material exposed to the combustion zone shall be of stainless steel construction. Dual heat exchangers utilizing stainless steel or aluminum alloy in only one of the heat exchangers are not permitted.
e. A variable speed cast aluminum pre-mix blower shall be utilized to ensure the optimum mixing of air & fuel between the air/fuel valve and the burner.

2. Pressure Vessel/Heat Exchanger
a. Boiler shall be capable of handling return water temperatures down to 40 F without any failure or corrosion for the life of the boiler.
b. Heat exchangers shall be constructed of 316L stainless steel fire tubes and tube sheets with a one-pass combustion gas flow design. The fire tubes shall be 5/8” OD with no less than 0.065” wall thickness. Upper and lower stainless steel tube sheets shall be no less than 0.313” thick. Access to the tube sheets and heat exchangers are available by burner and exhaust manifold removal.

3. Exhaust Manifold
   a. Provide materials and routing per manufacturer and code requirements. Provide drain in flue vent where recommended by manufacturer.

4. Controls:
   a. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant.
   b. The system shall control the boiler outlet header temperature within +2°F. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate temperature control with excellent variable load response. The system controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.
   c. Acid neutralization: Provide acid neutralizers as needed.

F. Controls:
   1. UL listed, electronic boiler control with adjustable reset ratios, adjustable offset to raise or lower reset curve, adjustable outdoor cutoff, night set back, minimum boiler water temperature adjustment, setback clock and adjustable morning warm up, manual override, LED indication of Setback, Bypass and On.
   2. Provide standalone controls by manufacturer. Controllers shall have software interface with BAS to reset temperatures and schedules. Provide communication gateway if required.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install boilers level and plumb, according to manufacturer’s recommendations.

B. Install boilers on 4-inch thick concrete base, 4 inches larger on each side than base of unit.

C. Install natural gas-fired boilers according to NFPA 54-96. Connect gas piping full size to boiler gas train inlet. Install with a union and dirt leg.

D. Connect heating water piping to boiler with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valve to nearest floor drain.

F. Controls:
   1. Wire boiler burner so it cannot fire unless heating water-circulating pump is running.
   2. Boiler shall be started and stopped automatically through the boiler control panel. Outdoor temperature sensor shall enable reset of heating water temperature in accordance with the following schedule:
      
      | Outdoor Air Temperature | Heating Water Temperature |
      |-------------------------|--------------------------|
      | 70 degrees F             | 140 degrees F            |
      | 0 degrees F              | 190 degrees F            |

   3. Wire boiler burner through flow switch in heating water loop to prevent boiler operation until positive flow is proven.
   4. Low water cutoff switch shall shut down boiler operation when water level drops below limit.
5. Automatic high limit shall shut down boiler operation when water temperature exceeds 200 degrees F (adjustable). Manual reset high limit shall shut down boiler operation when water temperature exceeds 205 degrees F (adjustable).
6. Install emergency shutdown switch near boiler room exit door. Wire switch through the burner controls.
7. Boiler shall have the capability for external hot water reset and enable via the BMS.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Test boiler performance and adjust boiler combustion efficiency to meet manufacturer’s recommendations.

1. Measure and record the following:
   a. Gas pressure on manifold.
   b. Combustion air temperature at inlet to burner.
   c. Flue gas temperature at boiler discharge.
   d. Flue gas carbon dioxide and oxygen concentration
   e. Natural flue draft.

B. Flush and clean boilers according to manufacturer’s instructions.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide 2 hours of instruction to university’s representative. Include operation of boiler including accessories and controls, procedures for startup and shutdown, troubleshooting, servicing, and preventive maintenance. Review data in the maintenance manuals.

END OF SECTION 23 52 00
SECTION 23 57 00 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes standards for heat exchangers, accessories, and trim.

1.2 SYSTEM DESIGN REQUIREMENTS

A. The campus central steam distribution will provide the source for producing clean steam, heating water, and domestic hot water for the buildings whenever possible.

B. Provide steam in shell and water in tubes to convert steam heat to hot water for hydronic heating systems.

C. Hot Water Heating Systems:
   1. Design hot water heating system with duplex converters and duplex main circulating pumps each capable of meeting the load individually.
   2. Locate heat exchangers to allow removal of tube bundles without interference.
   3. Provide air separators on systems.
   4. Reset hot water temperature based upon outdoor air temperature and control by the BAS.

D. Domestic Hot Water Heaters: Where steam is available, provide an instantaneous steam heat exchanger. Gas fired, or small electric heaters are acceptable with approval of the University Project Manager.

E. Steam Humidification:
   1. Use clean steam generators for humidification.
   2. Humidifiers shall be self-cleaning if available as an accessory.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Shell and Tube Type and Plate and Frame Type Heat Exchangers
      a. Bell & Gossett ITT
      b. Alfa Laval.
      c. Armstrong
      d. Triangle Tube
   2. Vertical Flooded Tube (application subject to the university Approval during design):
      a. Maxi-Therm
      b. Advanced Steam
   3. Steam to Steam Generators:
      a. Cemline

2.2 MATERIALS, GENERAL

A. Shell and Tube-type Heat Exchanger:
   1. Tubes: U-tube type with 3/4 inch OD minimum seamless copper tubes suitable for 250 psig working pressure.
   2. Shell: Steel with threaded or flanged piping connections and necessary tappings, steel saddle and attaching U-bolts, prime coated.
   3. Heads: Cast iron or fabricated steel tube sheets threaded or flanged for piping connections.
5. Domestic water application: provide stainless steel double wall exchanger.

B. Plate and Frame Heat Exchangers:
   1. General: Pre-assembled, pressure tested at the factory, and flushed clean, ready for connection to piping.
   2. Designed, fabricated, and tested for operation in accordance with the ASME Unfired Pressure Vessel Code, Section VIII, Division 1, including the latest addenda and code stamped.
   3. Enclose plate rack in a removable painted, rust protected carbon steel metal shroud designed to protect the plate rack from debris and damage.
   4. All exterior steel surfaces shall be sharp steel shot blasted followed by one coat of two part epoxy spray enamel baked at 250 degrees F.

C. Clean Steam Generators:
   1. General: Unfired, skid mounted, packaged steam to steam generator constructed of welded steel, with copper tube bundle.
   2. Tank: Designed, constructed, and stamped to meet requirements of ASME Code Section VIII for Unfired Pressure Vessels.
   3. Tube Bundles: U-tube design pitched and arranged to enable exterior cleaning.
   4. Insulation: Cover shell with 2-inch fiber insulation and protected by a zinc-plated sheet steel jacket.
   5. Controls: Provide electrical signal to the steam regulator valve. Provide liquid level controls to the feed water pump or valve. Provide electrically steam regulator valve with bypass connections, strainers and steam traps.
   6. Gauges and Valves: Provide unit with gage glass to permit visual inspection of water level. Provide thermometers or steam gages to monitor unit performance. Provide safety valves per ASME Section I Boiler Code. Provide blow-off valves in tandem arrangement on the bottom of the shell.
   7. Supply water shall be softened through an independent ion exchange softener

D. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

2.3 Domestic Hot Water Heaters:
   A. Instantaneous heaters shall have feed-forward control. Selection shall be based upon 2 to 15 psig inlet steam, ductile iron shell with copper coils.
   B. Floor mount instantaneous water heaters on custom fabricated frames made of 1-1/2 inch angle iron, and all components shall be contained within the outside dimensions of the skid frame.
   C. Valve plugs shall be manufactured of Hastaloy C with finishes <16 RMS.
   D. Pins and retainers shall be constructed of Monel or Stainless steel.
   E. Final selection will be based on space requirements, hot water requirements, and steam availability.
   F. Electric Storage tank water heaters are unacceptable.
   G. Heat exchanger shall not use arsenic or antimony.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
   A. Install in accordance with manufacturer’s instructions.
B. Install to permit removal of tube bundle with minimum disturbance to installed equipment and piping.

C. Support heat exchangers on welded steel angle from floor structure above.

D. Pitch shell to completely drain condensate.

E. Pipe relief valves to the nearest roof or floor drain.

F. Pipe drain valves to nearest floor drain.

G. Steam Piping: Provide piping as indicated, including control valve with 3-valve bypass, strainer, and pressure gauge on inlet; condensate dirt leg steam trap with 3-valve bypass, strainer and check valve on outlet; air vent or vacuum breaker on shell.

H. Water Piping: Provide piping as indicated, including union, shutoff valve, and thermometer on inlet and outlet. Pipe relief valve outlet to floor drain.

I. Steam-to-Water Heat Exchanger Trim:
   1. Shell: Pressure gauge tapping with pigtail siphon, vacuum breaker.
   2. Water Inlet: Thermometer well, pressure gauge tapping, valved drain.
   3. Water Outlet: Thermometer well for temperature regulator sensor, ASME rated pressure and temperature relief valve, thermometer well, pressure gauge tapping.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer’s touch-up paint.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide factory start-up services for the Steam to Steam generator to witness system start-up and check the performance of all controls and to provide operation and maintenance instruction of the equipment.
SECTION 23 60 00 - LABORATORY PIPING SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Air Systems:
   1. Control air shall be provided from individual building air compressors. Control air compressors shall be oil free dual motor/compressor type rated at 150%.
   2. Control air must be clean and dry. Compressor must be filtered and dried. Air drier may be refrigerated or desiccant style. Provide bypass piping and valves for servicing dries and filters and tank with control air system in operation.
   3. Oil separator shall be sized to accept one crank case full of oil.
   4. BAS shall monitor system.

B. Process or Lab Air System:
   1. Process air is not available from a campus central air system. A building duplex compressor will be as the preferred source.
   2. Process air compressors shall be selected to operate with a receiver pressure of 125 to 150 psig with pressure reducing valve to the designated system operating pressure. Install a pressure relief valve on all reduced pressure systems, set for 25 psig over reduced pressure.
   3. Piping systems shall be zoned appropriately and be provided with zone isolation valves. Compressed air piping should be sized on the basis of number of outlets, using a figure of 0.5 cfm at 40 psig per outlet. Diversity will vary from 100% simultaneous use in student labs to 20% to 30% in research labs. System loss should not exceed 5 psig loss at estimated demand. Any continuous demands shall be to the above quantities.
   4. BAS shall monitor system.

C. Vacuum Piping System:
   1. Vacuum piping should be sized on the basis of inlets. Use a figure of 1 cfm per outlet and 40% simultaneous use for typical laboratory rooms.
   2. Friction loss should not exceed 5 inches of mercury column drop at estimated demand of system. The above should be modified to meet special conditions and types of rooms or service
   3. Extend vent for vacuum pump up thru the building roof.
   4. BAS shall monitor system.

D. Distilled or Deionized (DI) Water Systems:
   1. Laboratory areas may require distilled or DI (deionized) water systems. The water still may be provided by the Department or furnished by the project. The still may be steam or electric powered depending upon demand and availability of steam. Utilities shall be provided by the project to the still which include domestic cold water, electrical power and steam. The distribution system shall be polypropylene Schedule 40 piping from tank to laboratory benches with appropriate gooseneck faucets made of, or lined with, polypropylene or other inert material. Isolation valves shall be provided at all branches for servicing and all DI water outlets.
   2. Laboratory areas may require DI (deionized) water systems. The distribution system shall be polypropylene pipe with socket weld fuse joints with mechanical joints on all service branches. The DI cartridge systems will be provided and serviced by a vendor under existing purchase order contracts. The quantity and quality of DI water shall be established by the user in cooperation with the University Project Manager. System shall have the ability to provide 18.0 megohm/cm quality water. Minimum water quality to users shall never be below 1.0 megohm/cm. Utilities shall be provided by the project to the DI system which includes domestic cold water and an electrical power outlet. Sometimes the DI system will be located in laboratories other times it may be centrally located in an equipment room. The distribution system shall be polypropylene Schedule 40 piping to laboratories with appropriate gooseneck faucets made of, or lined with, polypropylene or other inert material. The system will be under domestic water pressures or pump
3. Systems shall be automated to produce water within the required parameters. There shall be no less than 40 psi pressure at every user point. Circulate water at no less than 3 feet per second, with a maximum dead leg of 3 times the pipe diameter. Provide isolation valving at each service branch. All deionizing tanks shall be exchangeable for off-site recharging to include a backup bank of tank(s) with valving on a hard-piped manifold. Controls will be electro-mechanical in nature, with user serviceable parts. A dry contact for “no flow” alarm will be provided for connection to BAS systems. Pumps shall be stainless steel in construction. All control panels must be UL Listed and enclosures will be NEMA-4 rated. Isolation valving must be installed so any serviceable part can be bypassed and serviced without a total shutdown of the system. Pressure gauges will be installed at inlets and outlets of filters and pumps which will be user serviceable with a gpm gauge for a running total of DI water produced. Storage tanks will be polyethylene (HDPE) type, with a convex bottom. A spare parts list will be furnished with each installation, including a list of sources for their purchase.

4. Provide a resistivity monitor on the supply and return side of the DI system. Provide sampling valves at all major water processing equipment including, but not limited to, water softener, carbon filter, reverse osmosis, UV, ultra filter, and deionization

5. BAS shall monitor system.

E. Nitrogen Systems

1. General: All piping, fittings, valves, outlets, and any equipment through which medical gas or vacuum passes shall be supplied by the manufacturer especially cleaned and prepared for medical gas service in accordance with CGA Pamphlet G-4.1 and received labeled and sealed on the jobsite. On-site cleaning is not acceptable. Any prewashed item on which the seal has been broken before installation shall be removed from the site and shall not be used on this project.

2. Above Ground Piping: Seamless medical gas copper tubing, Type L, hard temper, ASTM Designation No. B-819 bearing one of the following markings: OXY, MED or OXY/MED.

3. Copper Tubing Fittings: Wrought copper solder-joint (95-5 fin antimony no lead) pressure fittings for brazed joints, ANSI Designation B16.22.

4. Valves: Union type three-piece construction, screwed, 400 lb. rated, with teflon seat, seals, packing, and chrome plated brass ball with service identification on valve handle.

5. Protective Casing for Under Ground Piping: Encase piping in a Schedule 40 galvanized steel airtight casing coated with extruded high density polyethylene coating applied with hot thermoplastic adhesive on clean pipe. X-Tru-Coat by Pipe Line Service Corporation, General Coatings, Inc. Field Joints, Fittings: Wrap with coal tar resin tape. Provide isolation supports between the pipe and casing at 6'-0” on center.

6. Protective Casing for Above Ground Piping: Encase piping in a Schedule 40 galvanized steel airtight casing where piping is installed in hazardous areas or areas subject to damage. Provide isolation supports between the pipe and casing at 6'-0” on center.

7. Brazing Alloy and Thread Sealant: Brazing filler metal ANSI/AWS A5.8 with a melting temperature in excess of 1000°F (538°C).

8. BAS shall monitor system.

F. Liquid Nitrogen Systems

1. Piping: The piping system shall be a flexible stainless steel static vacuum insulated system - VBS Industries StatiFlex system. Piping shall consist of two corrugated stainless tubes inside one another separated by a multilayer superinsulation and laminar radiation shielding. Piping shall have a clear plastic outer protective covering for abrasion resistance.

2. Valves and other fittings: All pipe sections shall be continuous lengths up to sixty feet or as the layout specifies and joined together with bayonet couplings. Field welded joints are not permitted. Components such as bayonet couplings, tee assemblies and point of use valves shall be rated for cryogenic service and of the same manufacture as the cryogenic piping manufacturer.

3. Cool-down losses for piping shall not exceed 8 btu's per foot and steady state losses for piping shall not exceed 1 btu per foot per hour.
4. Piping drops to lab equipment shall terminate with gas trap end assembly, bronze extended bonnet cryogenic valve with integral safety relief valve assembly and vacuum insulated stainless steel flex hose for equipment connection.
5. BAS shall monitor system.

G. Animal Watering Systems
1. An automatic watering system to all animal housing rooms.
2. Water is RO with acidification.
3. Automatic watering system is flow thru or filtered recirculation system.
4. Stainless steel manifold distribution designed in a way to prevent “dead legs.”
5. System shall be equipped with a programmable flush system for each rack and be centrally monitored for pressure or leaks.
6. System should be designed to include treated storage tanks that are sized accordingly to provide minimum of 48hours of animal drinking water (when facility is at full capacity) in an emergency.
7. BAS shall monitor system
8. Provide Edstrom or SE Labs.

H. Medical gas piping and compressed air piping shall be:
1. Seamless ASTM B-819, type K or L hard drawn seamless medical gas copper tubing.
2. Fittings shall be wrought copper, brass or bronze designed expressly for brazed connection, compliant with ANSI B16.22.
3. Pipe (Tube), fittings, valves, and other components shall be specially cleaned for oxygen service in a facility equipped to clean, rinse, and purge the material in accordance with the requirements of NFPA 5.1.10.1.1 and received on job site cleaned and capped. On site cleaning of the interior surfaces of tubes, valves, fittings, and other components is not allowed.
4. Brazing alloy shall be BCuP-5 Brazing alloy or equivalent alloy with at least 1000 degree F melting point.
5. O2 piping to be certificated in accordance with NFPA and current Code.

I. Gas/Cryogenic Tanks:

J. Compressed Gas Tanks (Unfired Pressure Vessels and Includes Air Receivers):

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
1. DI faucets:
   a. Water Saver (preferred)
   b. Cambridge Brass

2.2 MATERIALS GENERAL

A. Air Systems Piping:
1. Air piping shall be hard drawn type “L” copper tubing with wrought copper fittings and lead free soldered joints.
B. Deionized (DI) Water:
   1. Provide DI water piping system that is looped with a circulation pump. Complete system shall be unpigmented polypropylene with polypropylene stainless steel valves and accessories.
   2. The system shall provide 18.0 and not less than 1.0 megohm/cm quality water. Provide complete system including, but not limited to, the following:
      a. One automatic backwashing granular activated carbon filter. Filter shall be used for chlorine and organic removal at a flow rate of 30 gpm.
      b. Supply one, cartridge type, sediment filter housing constructed of 316 SS, electro-polished. Housing shall use one micron (minimal) filter cartridges. The empty housing flow rate shall be 30 gpm at a pressure loss of less that 2 psi.
      c. Supply sufficient grain tribed deionizers. Each tribed deionizer shall consist of one cation, one anion (strong base), and one mixed bed.
      d. Tanks shall be stainless steel or constructed of non-corrosive fiberglass surrounding an inner-molded lining of ABE plastic. Supplies shall be capable of regeneration of resins within the tank so that no U. of C. Resins are mixed with other resins. Supplier shall have a 24 hour emergency response capability include 1,000,000 ohm quality indicator light. Tank fittings shall be quick-disconnect, union style, and be made of inert materials.
      e. Supply enclosed annular head, flat bottom storage tanks. Tanks shall be factory steam cleaned. Tank shall come complete with all necessary fittings and shall be vented.
      f. Supply one level control with high level cutoff, low level pump cutoff, and mid-level fill. Mid level will energize n/c solenoid on the make-up line and cut power to the DI water recirculation pump. High level will close solenoid valve and start DI water recirculation pump.
      g. All necessary pumps
      h. Glycerine filled gauges with ss stems.
      i. Quality Monitor/Controller 35,000-5,000,000 ohm/cm 0.1 constant cell, meter, 10’ cord.
      j. All necessary controls and hardware to make system complete.
   3. Polishing units will be required at the lab outlet

C. Process or Lab Air System Piping:
   1. All process or lab air lines shall be Type “L” copper with brazed joints, with silver braze material.
   2. All process or lab air piping to be silver soldered.

D. Vacuum Piping:
   1. All vacuum piping shall be Type “L” copper with brazed or soft solder joints.

E. DI Socket Welded Piping:
   1. Polypropylene Pipe For D.I Water Systems
      a. All high-purity water piping as shown on drawings shall be socket-fused, virgin natural polypropylene (containing no regrind material) as manufactured by IPEX. The complete system of piping, valves, fittings, faucets, pipe supports and fusion equipment shall be supplied and warranted by a single manufacturer.
      b. Physical dimensions and properties of Enpure PP Schedule 40 and 80 Pipe and fittings shall meet the requirements of ASTM D 1785 and CSA B 137.3.
   2. Polypropylene Material
      a. Piping shall be manufactured in 10’ or 20’ (3m or 6.1m) lengths to Schedule 40 and Schedule 80 dimensions from virgin, unpigmented, Type 2 high-impact copolymer polypropylene conforming to ASTM D 4101, using no antioxidants or plasticizers. Piping shall be capped at each end and boxed for protection and cleanliness at the point of manufacturing.
   3. Polypropylene Fittings For D.I. Water Systems
      a. Fittings shall be manufactured from virgin, unpigmented Type 2 high-impact copolymer polypropylene conforming to ASTM D 4101, using no antioxidants or plasticizers. Fittings shall be designed for socket fusion utilizing socket fusion tools and shall have a working design pressure of 150 psi at 73°F (1,000 kPa @ 23°D). All fittings shall be packaged in polybags at the point of manufacturing to preserve fitting cleanliness.
4. Polypropylene Valves
   a. All valves shall be manufactured from virgin, unpigmented type 1 Homopolymer polypropylene conforming to ASTM D 4101, using no antioxidants or plasticizers that could compromise water quality. Valves shall be designed for socket fusion utilizing IPEX socket fusion tools and shall have a working design pressure of 150 psi @ 73°F (1,000 kPa @ 23°C). All ball valves shall be double-blocking type with 0-ring cushions under the PTFE seats, in-line micro adjustment capability and incorporate a spanner wrench in the handle. All diaphragm valves shall be weir-style featuring smooth (non-drilled) GRF bonnets with integrated fasteners (for cleanliness) and rising position indicator. All valves with EPDM diaphragms shall feature concentric ridges on valve body and smooth diaphragms. All valves with PTFE diaphragm shall feature machined (smooth) bodies and rigid PTFE diaphragms for positive seal and longer cycle life. All ball check valves shall be single union design with micro adjustable locking seat carrier.

5. Fusion Equipment
   a. All piping supports shall incorporate Cobra clips manufactured from U.V. stabilized polypropylene and designed to allow free axial pipe movement during expansion and contraction of a pipe system. Support spacings shall be to the manufacturer’s recommendations for the design temperature of the system.

6. Joining Method
   a. Installation shall be in accordance with the contract drawings, the manufacturer’s recommendations and the local building codes. The entire system shall be installed stress free and in proper alignment, with due allowance for expansion and contraction.
   b. The water-testing requirements on any complete piping system vary dramatically depending on the operating pressure, temperature, installation conditions, jointing method and the proposed service medium. If the testing is not determined by the engineer or governed by regulatory code, the manufacturer should be contacted.
   c. All polypropylene pipe shall be jointed by the following methods:
      1) Hand Held Tool.
      2) Bench Fusion Machine completion of the project.
      3) Contractor to provide both a hand held tool and bench fusion machine to the university at completion of project.
      4) When any of the following is required – larger sizes, high volume joints per day or absolute consistency of the welds – the use of a bench fusion machine (manual or hydraulic) is recommended.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
   A. Plumbing: No lead solder shall be utilized.
   B. All piping installed per most recent IPC.

3.2 HVAC Control Air Systems:
   A. Provide instrument air tubing with check and hand valves to expansion tanks with Schraeder fittings and hose.
   B. Leak-test the pneumatic system mains to 150% of maximum system pressure for 24-hours. Check calibration of instruments. Recalibrate or replace.

3.3 TESTING, CLEANING, AND CERTIFICATION
   A. All process or lab air system piping shall be sterilized prior to use.
B. System Disinfection

1. On system startup provide disinfection of the entire high purity water system. For the reverse osmosis central system, provide for disinfection to be the responsibility of the water system manufacturer. For the distribution piping, disinfection is the responsibility of the Mechanical Contractor, coordinated with reverse osmosis system manufacturer.

2. Achieve disinfection by maintaining a concentration of not less than 200 ppm of sodium hypochlorite for a minimum contact time of four hours or a 1% solution of Minncare cold sterilant for 1 hour. Verify concentrations at all drops during dwell time. Then flush and fill the system with reverse osmosis/DI water only. Test all drops to ensure the system has been properly flushed.

3. After system and distribution disinfection, bacterial samples shall be taken from the storage tank, after the final filters and at four points of use, one point being the last distribution point before returning to the storage tank, and one being the furthest point from the RO/DI equipment room.

END OF SECTION 23 60 00
SECTION 23 64 16 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Chillers included in this section are intended for structures that are constructed outside the practical limits of the campus central chilled water system or are chillers utilized to provide chilled water for a specific process.

B. Do not locate chillers near noise sensitive areas.

C. Monitor machine room and sound audible alarm if refrigerant concentrations exceed 10 ppm.

D. Compressors over 100 ton Capacity:
   1. Motors and Starters:
      a. Dual winding, wye-delta design with matching two-step, closed transition, time-delay starting switch gear is preferred. Provide an auxiliary timer in the starting circuit.
      b. Set timer to limit starts to a minimum of 30 minutes apart or greater.
      c. An auto-transformer with reduced voltage start is an acceptable alternate starter.
      d. Provide heat sensors on all motors in the windings for thermal protection.
   2. Full-running Protection:
      a. Specify compressors equipped with high and low pressure safety cut out, external overload protection, thermal protection, and low oil pressure.
      b. Manual reset type safeties which cause an electrical lock-out of the starting circuit when it has tripped, with an indication of which safety device has operated.
   3. Gauges and Lubrication:
      a. Include gauges, indicating high side, low side and oil pressures. Gauges are not required if unit is equipped with a micro-processor control which shows pressures at control panel.
      b. Forced-feed lubrication system with filter, cooler, and visual inspection port in the oil reservoir.
   4. Heaters:
      a. Provide crankcase heaters wired on a separate electrical circuit.
      b. Provide oil pump starter wired on a separate electrical circuit.
   5. Refrigerant Transfer: Provide provisions for pump out/down into unit-mounted receiver if application warrants.
   6. Pressure Relief: Show on drawings, safety valve pressure relief piping, vented to outdoors in accordance with ASHRAE 15. Provide self-closing, resealing type pressure relief valve.

E. Compressors of 60 to 100 ton Capacity:
   1. Semi-hermetic, reciprocating type, rotary screw, helical rotor or scroll.
   2. Full-running Protection:
      a. Specify compressors equipped with high and low pressure safety cut out, external overload protection, thermal protection, and low oil pressure.
      b. Manual reset type safeties which cause an electrical lock-out of the starting circuit when it has tripped, with an indication of which safety device has operated.
   3. Include gauges, indicating high side, low side and oil pressures. Gauges are not required if unit is equipped with a micro-processor control which shows pressures at control panel.
   5. Oil reservoir sight glass.
   6. Replaceable refrigerant filter-dryers in liquid line.
   7. Hydraulic capacity control by cylinder unloading for adjustments to load fluctuations.
   8. Positive unloaded start.
   9. Discharge muffler.
   10. Internal vibration isolation.
11. Closed transition starting switch-gear. Part-winding is acceptable.
12. Refrigerant Transfer: Provide provisions for pump out/down into unit-mounted receiver if application warrants. If condenser will hold the full charge, this is an acceptable alternative.

F. Compressors under 60 but over 15 ton capacity:
1. Hermetic or semi-hermetic, reciprocating type, helical rotor or scroll.
2. Inherent thermal overload protection for motors.
3. Include gauges, indicating high side, low side and oil pressures. Gauges are not required if unit is equipped with a micro-processor control which shows pressures at control panel.
5. Oil reservoir sight glass.
6. Replaceable refrigerant filter-dryers in liquid line.
7. Hydraulic capacity control by cylinder unloading or staging of multiple compressors.
8. Positive unloaded start.
9. Discharge muffler.
10. Internal vibration isolation.
11. Closed transition starting switch-gear.
12. Refrigerant Transfer: Provide provisions for pump out/down into unit-mounted receiver if application warrants. If condenser will hold the full charge, this is an acceptable alternative.

G. Compressors between 7-1/2 and 15 ton capacity.
1. Same requirements as 15 to 60 ton compressors except that cylinder unloading and unloaded start features are not required on the small units.

H. Compressors below 7-1/2 tons:
1. Same requirements as 7-1/2 to 15 ton compressors except gauges are not required.

I. Condensers:
1. Select air cooled condensers with sufficient capacity to compensate for altitude deration of 5200 feet and 105 degree F inlet air temperature.
2. Do not specify vertical blow-type condenser fans for systems that operate during winter.
3. For winter operation, specify a horizontal blow-type condenser fan with a weather-protecting shroud designed to prevent possible blade icing and unbalance.
4. Arrange water-cooled condensers so that tubes can be rodded without hindrance from walls, piping, or equipment.
5. Provide low ambient accessory package to consist of variable speed condenser fan control based upon outside air temperature or refrigerant gas temperature/pressure on air-cooled condensers with intermittent winter cooling requirements down to 40 degree F outside air temperature. Provide thermostatic expansion valves with these systems. Orifice type valves are not permitted.
6. Provide flooded condenser control with liquid receiver and 3-way head pressure control valves on systems requiring continuous and critical winter cooling operation. Provide electronic expansion valves.

J. Chillers:
1. Centrifugal chillers with oil coolers, which are cooled with chilled water, should have pressure and temperature gauges installed on inlet outlet of chiller out of the influence of the oil cooler circuit.
2. Install the following components on all chilled and condenser water systems.
   a. Chiller Water Temperature Sensors:
      1) Supply temperature sensor
      2) Return temperature sensor
   b. Low Water Temperature Cut-out.
   c. Water Flow Sensors:
      1) Chiller water system
      2) Condenser water system
d. Relief Valves.
3. Install noise and vibration apparatus in accordance with state and federal regulations, and ARI Standard 575-87.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Centrifugal or Rotary Screw Chillers:
   a. Carrier.
   b. McQuay.
   c. Trane.
   d. York.

2.2 MATERIALS, GENERAL

A. Centrifugal or Rotary Screw Chillers:

2. Factory assembled and wired consisting of one or compressors, an evaporator or cooler, an air or water-cooled condenser, safety controls and operational controls.
3. Refrigerant: R134a; provide full operating charge of refrigerant and oil. Provide refrigerant charging port.
4. Compressor: Hermetic or semi-hermetic, rebuildable.
5. Motor: Refrigerant cooled, hermetic or semi-hermetic motor; or open, drip-proof induction motor; with the following features: Overvoltage protection, Undervoltage protection, Single-phasing protection, Current-overload protection.
6. Evaporator: Shell and tube cooler with refrigerant totally enclosed by shell; water in tubes.
   a. Shell: Carbon steel plate.
   b. Cooler Tubes: Seamless copper; expanded into tube sheets; individually replaceable; externally finned.
   c. 300 psig refrigerant working pressure.
   d. 150 psig water side working pressure.
   e. Insulation: factory applied, ¾-inch thick, flexible elastomeric insulation evaporator, suction lines, and other surfaces where condensation might occur.

7. Water Cooled Condenser: Shell and tube condenser with water enclosed in tubes; refrigerant enclosed by shell.
   a. Shell: Carbon steel plate.
   b. Cooler Tubes: Seamless copper; expanded into tube sheets; individually replaceable; externally finned.
   c. 300 psig refrigerant working pressure.
   d. 150 psig water side working pressure.
   e. Safety and operating options include the following; pressure relief safety valve, purge valve, subcooler circuit.

8. Air Cooled Condenser: Factory assembled, wired, and tested; consisting of casing, air-cooled condenser coils, fans, and controls integrated with compressor operation.
   b. Fans: Propeller type, statically and dynamically balanced; vertical discharge.
   c. Fan Motor: Direct drive, weather proof, with bearings permanently lubricated, and having built-in current and thermal overload protection.
   d. Condenser Coil: Copper tubes with mechanically bonded aluminum fins.

B. Controls:

1. General: Manufacturer’s standard microprocessor-based chiller controls.
2. Temperature Controls: Modulating slide valve to maintain chilled water temperature set point without hunting within throttling range. Include the following features:
   a. Throttling Range: Full load to 10 percent of full load.
b. Chilled water temperature control.
c. Chilled water temperature setback.
d. Load limit controller.

3. HVAC Controls: Furnish appurtenance to monitor and control chilled water set point, to monitor condenser water set point, and to monitor chiller alarms from building automation system.

4. Safety Controls: Automatic and Manual reset controls to perform the following functions:
a. Low evaporator pressure cutout.
b. Low chilled water temperature cutout.
c. Low oil sump temperature cutout.
d. Low oil pressure cutout.
e. High oil temperature cutout.
f. High condenser pressure cutout.
g. Water Flow Interlock: Water flow switch to prevent starting compressor without chilled and condenser water flow.

5. Power Controls: Manufacturer’s standard, unit mounted, factory wired, single-point connection, with the following power control options:
a. External overload protection.
b. Control circuit fuse.
c. Power terminal block.
d. Lockout restart timer.
e. Combination controller and disconnect.

6. Interface to campus BMS?

C. Refrigerant Monitor:

1. UL 2075 refrigerant monitor to continuously monitor mechanical equipment rooms for refrigerant concentrations between 0 and 1000 PPM. Unit enclosed in NEMA 4 cabinet. Monitor shall draw room air though an infrared photo-acoustic sensing device allowing accurate measurement of refrigerant vapors. Unit shall be inherently zero-stable and include sample filters. Monitor shall signal alarm levels at three concentration levels plus a unit "trouble" alarm that indicates internal problems with monitor.

2. Interface Module: Minimum of a backlit, 2 line, and 16-character language display. Module capable of remote mounting.

3. Input: 4-20 mA.

4. Output: 0-10vdc and a 4-20 mA analog output proportional to the displayed refrigerant concentration.

5. Latched alarms re-settable from a remote source via a contact opening.

6. Accessories: Alarm package consisting of 3 flashing lights and audible alarm mounted in one assembly for remote mounting.

PART 3 - EXECUTION

3.1

3.2 INSTALLATION, GENERAL

A. Install chillers on 4-inch thick concrete base, 4 inches larger on each side than base of unit. Anchor chiller and vibration isolators to concrete base.

B. Maintain manufacturer’s recommended clearance for service and maintenance.

C. Connect piping to chiller with shutoff valves and flanges at each connection.

D. Label the amount of refrigerant in the system in pounds.
E. Provide flanges at each condenser and chilled water connection to chiller. Provide removable sections to permit removal for access to tube bundles for cleaning. Pipe sections shall be no longer than 4 feet or shall consist of a removable elbow in order to be removable without heavy equipment.

F. Place isolation valves on piping to permit removal of sections described above without draining of chilled or condenser water.

G. Controls:
   1. Wire chiller so it cannot start unless chilled water and condenser water circulating pumps are running.
   2. Start and stop chillers automatically through the chiller control panel.

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Test each chiller before shipment. Provide certified test report to confirm performance, include capacity test, power consumption test, and Part Load Value at ARI standard conditions.

B. Complete manufacturer’s installation and startup checklist.

C. Test and adjust controls and safeties.

D. Flush and clean chillers according to manufacturer’s instructions.

3.4 COMMISSIONING (DEMONSTRATION)

A. Provide services of a factory authorized service representative to provide startup services and to demonstrate and train the university’s representative. Before start-up, manufacturer shall scope the chiller tubes to ensure they are not damaged or twisted.

B. Provide 4 hours of instruction to the university’s representative. Include operation of chillers including accessories and controls, procedures for startup and shutdown, troubleshooting, servicing, and preventive maintenance. Review data in the maintenance manuals.

END OF SECTION 23 64 16
SECTION 23 65 00 - COOLING TOWERS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. General Information:
   1. Use outdoor conditions of 95 degree F dry bulb and 64 degree F wet bulb to size cooling tower capacity.
   2. Consider closed loop, evaporative sprayed cooling towers to use in conjunction with heat exchangers for systems having winter cooling requirements.

B. Remote Sump:
   1. Allow minimum water level of 4 feet of suction head under operating conditions or greater, if required to meet NPSH of pump.
   2. Provide a minimum of 150 percent of drain down storage capacity.
   3. Drain down capacity to consist of volume of cooling tower water retention plus all piping exposed to freeze conditions.
   4. Provide ventilation in sump room to control humidity.

C. Provide ladders and safety cages to meet ANSI standards.

D. Provide manufacturer’s certification of tower cooling capacity, based on factory-performance tests, and provide performance curve plotting Leaving-Water Temperature (LWT) against Wet-Bulb Temperature (WBT).

E. Provide certification of tower wind resistance to withstand pressure indicated, in any direction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Baltimore Aircoil Co., Inc.
   2. Marley Cooling Tower Company
   3. Evapco

2.2 MATERIALS, GENERAL

A. General Information:
   1. Supply cooling towers with 2-1/2 inch minimum size drain outlet in bottom of sump and located on opposite side of suction outlet of sump. Pipe drain lines to nearest roof drain. Consider indoor sumps as an alternative with the benefit of cold weather operation.
   2. Provide tower sections with access ladders from top to bottom in accordance to OSHA standards.
   3. Locate tower fan motors outside of the air stream for access for maintenance and not in air stream. Fan motors shall utilize VFD for capacity control.
   4. Provide access openings to sumps, valves, motors, belts, sheaves sprays, etc.
   5. Provide water treatment piping with bleed solenoid valve, wye strainer and blow down valve upstream. Lockout timer shall have a 3-hour minimum setting.

B. Factory-fabricated Cooling Towers:
   1. General: Fabricate cooling towers using manufacturers’ standard design, materials, and construction in accordance with published product information, except as otherwise indicated.
2. Design structural system for the following live loading in addition to dead-loads and operating-loads.
   a. Wind Loading: 30 psf on exposed vertical surfaces.
   b. Earthquake Resistance: Acceleration on 1.0 G horizontally through the center of gravity.
3. Fabricate structural system including assembly of collecting basin and steel casings by one of the following methods:
   a. Bolt connections with fasteners having equal or better corrosion-resistance than the materials being fastened; seal joints to make a watertight enclosure.
   b. Weld connections and weld metal seams continuously to make unit watertight.
   c. Provide rigging supports on structure for final rigging.
4. Casings: Install galvanized steel, fabricated and installed by manufacturer to make tower watertight.
5. Provide integral type collecting basin with depressed side outlet sumps with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow and water makeup.
6. Wetted Surface Fill: Provide vertical sheets of polyvinyl chloride plastic having a flame spread rating of 5 per ASTM E 84 and fabricated into wave-formed configurations installed by the manufacturer to assure break-up of water into droplets.
7. Drift Eliminators: Provide vertical sheets of polyvinyl chloride plastic having a flame spread rating of 5 per ASTM E 84 fabricated by the manufacturer into a three-pass configuration to limit drift-loss to indicated maximum percentage of circulating-water flow-rate.
8. Louvers: Provide galvanized steel designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging.
9. Water Distribution System: Galvanized steel, open basin, gravity-flow type with plastic metering orifices; installed by manufacturer to ensure even distribution of water over wetted-surface-fill. Schedule 40 PVC pipe header and removable schedule 40 PVC pipe branches.
10. Nozzles: Provide removable plastic, brass or ceramic nozzles with a maximum pressure drop of 5 psi.
11. Basin Covers: Galvanized steel sheet, removable and with handles, installed by the manufacturer to prevent debris from entering basin and to inhibit algae growth by eliminating sunlight.
12. Inlet Screens: Galvanized steel mesh mounted in removable frames by the manufacturer.
13. Discharge Hoods: Galvanized steel, including access doors, fabricated and installed by the manufacturer to prevent the recirculation of discharge air.
14. Basin heaters: Provide electric immersion heaters including thermostat and low-water cutout, in a weatherproof enclosure, adequate for field wiring. Size basin heaters to maintain basin water at 40 degree F. (4.4 degrees C) at an ambient temperature of -10 degrees F. and with a wind velocity of 15 mph.
15. Handrails: Provide galvanized steel pipe rails of required height above tower. Include knee and toe rails of required diameter and heights.
16. Water Level Control: Provide electric float switch and solenoid make-up valve.
17. Flow Control Valves: Provide heavy duty cast iron, high capacity flow control valves for balancing flow to each distribution basin, and for shut-off during servicing. Do not install ball valves or other valve types that may trap water within the valve to prevent freezing conditions from damaging the valve when the system is not in operation.
18. Fans and Drives:
   a. Provide cast aluminum propeller fan of adjustable pitch type.
   b. Provide a gear-drive including speed reducer, with oil level sight glass.
19. Fan Bearings: Provide bronze sleeve bearings with extended external oil lines, sight glass and fittings.
20. Motor Type: Provide totally enclosed, fan-cooled energy efficient type motor. Rated for cooling tower duty service. Efficiency and construction shall comply with Section 23 65 00.
21. Assemble components by one of the following methods:
   a. Use galvanized or stainless fasteners and accessories to assemble components.
   b. Weld metal seams and joints.
c. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline-soluble rust preventative compound on ferrous parts that cannot be galvanized, including shafts and machined parts.

22. Finish components with zinc-coated metal surfaces using one of the following methods:
   b. Provide 2-1/4 oz. (per sq. ft. of sheet) zinc coating on basin and sump, after fabrication, by hot-dip galvanizing process. Coat abraded areas and welded areas of work with galvanizing repair paint.
   c. Apply to metal surfaces not galvanized, zinc-rich paint which has been tested and accepted by UL as being equivalent to hot-dipped galvanized steel.

23. Vibration Cutout Switch: On induced towers with propeller fans provide switch to de-energize fan motors if excessive vibration occurs due to fan imbalance.

24. For polymer-coated surfaces, electrostatically spray with thermosetting hybrid polymer fuse bonded to hot-dipped galvanized substrate during thermally activated curing stage. Provide polymerized metal surfaces that are capable of:
   a. When “X” scribed to base substrate, withstand 6,000 hrs. of 5% salt spray test according to ASTM B 117, with no blistering or chipping around intersection of scribes, nor any undercutting or creepage along scribes.
   b. When directly impacted with 160 in. lbs. from 0.625 in. radius impact tool, in accordance with ASTM D 2794, show no fracture or delamination.
   c. When exposed to 6,000 hrs. of continuous ultraviolet exposure, equivalent to 120,000 hrs. of normal sunlight radiation, show no cracking.
   d. When subjected to 200 thermal shock cycles between -25 and 180 degree F (-32 and 82 degree C), show no signs of deterioration.
   e. When exposed continuously for 6,000 hrs. to high pressure (60 psig) water jet, show no signs of erosion.

C. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which factory-fabricated cooling towers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. General Installation: Install cooling towers where indicated, in accordance with equipment manufacturer’s written instructions and with recognized industry practices, to ensure that cooling towers comply with the requirements and serve intended purposes.

B. Access: Provide access and service space around and over cooling towers as indicated, but in no case less than that recommended by the manufacturer.

C. Support:
   1. Install roof-mounted units on structural steel mechanical equipment stand. Anchor cooling tower to stand with removable fasteners.
   2. Install floor-mounted units on 4-inch high reinforced concrete pad, 6-inches larger on each side than cooling tower base. Cast anchor bolt inserts into pad.

D. Construct mechanical equipment stand as indicated, and in accordance with NRCA handbook and Accepted Roofing Knowledge.
E. Placement: Mount unit on vibration isolators if recommended by cooling tower manufacturer. Install gaskets or sealants between cooling tower cells. Level units to tolerance of 1/8" in 10'-0", in both directions.

F. Condenser Water Piping: Provide flanged or mechanical coupling connections to cooling tower, with flexible pipe connections if tower is mounted on vibration isolators. Pitch lines so water will drain into sump. Connect inlets to cooling tower with shutoff valve and balancing valve (if two or more inlets) Connect outlets with shutoff valves.

G. If the tower consists of more than one cell, in order to facilitate cleaning and maintenance, each cell shall have the capability to be completely drained and isolated from the other cell through a network of piping and valves. Provide equalizing piping between cells with automatic control valve.

H. Make-up and Water Piping: Provide flanged, mechanical couplings, or union connections to cooling tower. With flexible pipe connections if tower is mounted on vibration isolators. Pitch lines so that the water will drain into the sump. Connect to automatic fill valve with a 3-valve bypass, and backflow preventer.

I. Drain Piping: Connect drain, overflow, and bleed lines to cooling tower as indicated, full size of connection on cooling tower.

J. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s wiring diagram submittal to Electrical Installer.

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Testing: Test each cooling tower to show that it will operate in accordance with indicated requirements.

B. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer’s touch-up paint.

C. Verify that electrical wiring installation is in accordance with manufacturer’s submittal and installation requirements of Division 26 Sections. Do not proceed with equipment start-up until wiring installation is acceptable.

D. Start-up: Comply with manufacturer’s instructions for filling and start-up of operation, but not less than the following:
1. Verify lubrication of rotating parts; lubricate as needed.
2. Verify fan for correct rotation.
3. Verify that the motor amperage is in accordance with the manufacturer’s data.
4. Balance condenser water flow to each tower, and to each inlet for multiple inlet towers.
5. Adjust water level control for proper operating level.
6. Adjust bleed valve for indicated percentage of circulated water volume.
7. Balance equalizer lines between multiple towers (if necessary).
8. Adjust temperature controls and verify operation.

3.4 COMMISSIONING (DEMONSTRATION)

A. Provide services of a manufacturer’s technical representative for one 8-hour day to instruct the university’s personnel in operation and maintenance of the cooling tower.

B. Schedule training with at least seven (7) days notice to the Contractor, the University Project Manager and the Engineer of the training date.

END OF SECTION 23 65 00
PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. General:
   1. Locate roof-mounted equipment as inconspicuous as possible by placing equipment far away from edge of roof, painting, screening or a combination of these,
   2. Locate fans, motors, and drives for safe and easy access for periodic inspection and maintenance.
   3. Show air handling unit arrangements on schematic diagrams.
   4. Scheduled fan sound ratings where noise levels are critical.
   5. All fans shall be licensed to bear the AMCA Seals for Air and Sound Performance.

B. Fan specifications and accessories for all fans 12 inch and larger wheel shall include the following.
   1. Direct drive fans are preferred.
   2. Provide building air handling unit fans with external bearings only. Shafts 3/4 inches and larger shall have roller bearings. No internal bearings recessed into fan housing shall be allowed. All bearings shall be accessible for lubrication, maintenance, and replacement.
   3. Aluminum wheels are not allowed except for spark proof applications.
   4. Install weatherproof housing over motor and drive when exposed to weather. Metal interior casings and wheels shall be coated if fumes are corrosive.

C. Fan Vibration Isolation:
   1. Provide spring isolators either within the air handling unit housing or independently mounted to reduce the transmission of distributing vibration of the fan to the supporting structure by a minimum of 90%.

D. Drives:
   1. Single belt drives shall be utilized only on equipment with 1 Hp motors or less.

E. Air Handling Units:
   1. Inlet Louver: Shall be sized with 300 fpm face velocity to slow down the snow induced into the unit. Bird screen 1/2” x 1/2” shall be utilized in such a manner that vacuuming of the screen can be done.
   2. Air handling units shall be designed and installed with sufficient room to allow the installation of all control components including but not limited to preheat coil discharge air temperature averaging sensors.
   3. Architect and mechanical engineer shall coordinate the space requirements for the airflow monitoring equipment per the manufacturers required straight duct length to measure airflow
   4. Heat Recovery Coil: When applied, shall be a minimum 4-row coil with the face velocity not to exceed 600 fpm. Access for vacuuming on both sides.
   5. Preheat Coil: Steam coils shall be vertical tube with integral face and bypass. Steam control
   6. Valve shall be installed to modulate the flow of steam. All hot water preheat coils shall be pumped. Heating coils: Shall be located far enough from the heat recovery coil so that an averaging sensor can be located to measure the leaving air temperature
   7. Cooling Coil: Shall be located far enough from the preheat coil so that an averaging sensor can be located to measure the leaving air temperature.
   8. Air ratings are based on actual site elevation of 5200 feet.
   9. Any AHU with outside air intake:
      a. Provide low temperature detectors. The heating coil shall be located before the chilled water coil. Provide adequate space between coils for low temperature detectors. Low temperature reset should be accessible without the need for a ladder.
      b. Provide air blender.
c. Provide turbulators on heating coils.
d. Provide evaporative cooling section.
   1) Reference 23 76 00 Evaporative Cooling for more information.
   2) Direct evaporative section shall be sectioned for multi-staging.
   3) Section shall be located far enough from the cooling coil so that an averaging sensor
can be located to measure the leaving air temperature.
   4) Consideration given to bypass dampers for greater discharge temperature control.

10. Locate air handling equipment inside buildings.
11. Any fan coils with outside air:
   a. Provide low temperature detectors. The heating coil shall be located before the chilled
      water coil. Provide adequate space between coils for low temperature detectors.
   b. Low temperature reset should be accessible without the need for a ladder.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Air Handlers:
      a. Haakon (preferred)
      b. Energy labs
   2. Fan Coil Units:
      a. McQuay
      b. International Environmental

B. Air Handling Units:
   1. Panels:
      a. Low pressure casings, less than 1-1/2 inch static pressure: Single wall construction,
galvanized steel with 1-inch, 3/4-pound mat faced glass fiber insulation.
      b. High-pressure casings, above 1-1/2 inch static pressure inch sandwich panels filled with
insulation. Exterior panel sheet to be 18 gauge galvanized steel and interior panel sheets 22
gauge perforated galvanized steel.
   2. Access Doors: Same material and finish as cabinet with hinges, latches, handles, and gaskets.
      Provide neoprene gaskets around full perimeter of access doors. Doors shall be 24 inches wide and
50 inches high when possible. Provide view window with safety reinforcement mounted in access
doors. Doors shall open against the air pressure.
   3. Light: Marine type, vapor tight, incandescent light fixture. Each light controlled by an individual
      switch. Provide light in each fan section with an access door.
   4. Fan Section:
      a. Fan statically and dynamically balanced for continuous operation at maximum rated fan
speed and motor power.
      b. Shaft: Hot-rolled steel; turned, ground, and polished, with keyway to secure fan wheel hub.
      Shaft shall not pass through its first critical speed as the unit comes up to its rated rpm.
      c. Shaft Bearings: Greasable, self-aligning, pillow block type ball or roller bearings with L50
      rated bearing life of 200,000 operating hours. Factory lubricated and equipped with grease
      fittings extended to the motor side of fan.
   5. Coil Module:
      a. Insulated, 16 gauge galvanized steel casing for heating and cooling coils. Coil headers and
      return bends enclosed in casing. Coils accessible for service and removable through access
doors or removable panels.
      b. Coil performance certified in accordance with ARI 410.
      c. Water Coils: Drainable with threaded plugs. Serpentine with return bends or return headers.
      Coils tested to 300 psig air pressure under water. Coil circuited for counter flow of air and
water.
d. Steam Coils: Pitch coils for proper drainage of steam condensate. Coils tested to 300-psig air pressure under water.
e. Heating Coils: Provide turbulators on heating coils.

6. Filter Module:
   a. Galvanized steel filter racks, access door, and block-offs to prevent air bypass around filters.
   b. Provide minim 12” space between filter rack for installation of differential pressure gauge.

7. Dampers: Galvanized steel blade, air foil design, Low leakage dampers rated according to AMCA 500 shall not exceed 2 percent of air quantity at 2000 fpm face velocity through damper and 4-inch wg pressure differential.

9. Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

C. Total Heat Recovery Wheel
1. The energy recovery wheel shall be certified to ANSI/ARI Standard 1060 and bear the ARI 1060 label. Performance characteristics of the energy wheel shall be provided as defined by ARI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel’s entering air transfer rate (EATR) shall be less than the 3%. The amount of outside air transferred to the exhaust air shall also be reported to ensure proper fan and damper sizing. Wheel face velocity shall not exceed 900 fpm and pressure drops shall be less than 1.25” w.g.
2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The energy wheel media shall be constructed of synthetic fiber or polymer media. The media shall not be subject to corrosion in marine or coastal environments. The adsorbent shall be integrally bound into the media or impregnated into the media without the use of binders or adhesives. The adsorbent shall not be applied as a glued on surface coating and not susceptible to erosion, abrasion, or delamination. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. Energy recovery cassettes shall be UL-recognized components certified for mechanical, electrical and fire safety in accordance with UL Standard 1812.
3. Energy recovery media shall be provided in the form of removable segments. The media shall be effectively captured in segment frames providing a rigid and self-supporting matrix. Segments shall be removable without the use of tools to facilitate maintenance and cleaning as required. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting and diameter seals shall be adjustable. Seals shall be factory set.
4. Wheel drive motor shall be provided mounted in the cassette frame. Motor locations shall be as indicated on the schedule and drawings. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings. Wheel bearings shall be permanently sealed and lubricated.
5. Access doors shall be provided for the removal of wheel segments. Doors shall be located to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal.
6. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel’s recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel’s variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity.
7. Frost prevention shall be achieved by outside air bypass. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.
8. All controls for unit operation shall be by Division 23 09 00.
PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL:

A. Install equipment such that filters, motors, bearings, and belts can be easily serviced.

B. Install filters prior to starting fans.

C. Connections:
   1. Connect piping to air handling units with flexible connectors.
   2. Connect drain piping to condensate drain pans with deep trap. Route piping to nearest floor drain. Install cleanouts at changes in direction.
   3. Install flexible connections at inlet and outlet of fans connected to ductwork.

D. Locate motor disconnect within 3 feet of the motor.

E. Fan Drive:
   1. Align belts with proper tension prior to start-up.
   2. Final sheave shall be fixed. Balancing firm’s variable sheaves will be removed and replaced with the proper sized fixed sheaves.
   3. Original sheaves shall be changed when required for proper balancing.

F. Fans:
   1. Access shall be provided to allow cleaning of fan and blades without disassembling ductwork
   2. Install fans in accordance with manufacturer’s printed data. Prior to starting fan, clean ductwork and lubricate bearings.

G. Air Handling Units:
   1. Allow access for cleaning coils from both sides. Provide a means to catch and dispose of cleaning solutions with pipe to drain on larger coils.
   2. Provide space for removing and repairing coils and other components.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Clean fan interiors. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. Provide one (1) new set of filters to be installed by contractor at the time of system acceptance.

C. Provide air handler schedule listing for each unit, location, filter sizes, coil sizes, motor Hp, belt size, and areas served.

3.3 COMMISSIONING (DEMONSTRATION)

A. Provide 2 hours of operating instructions for each fan and air handling unit. Include procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance. Review data in the operation and maintenance manuals.

END OF SECTION 23 70 00
SECTION 23 76 00 - EVAPORATIVE AIR-COOLING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. For additional information, also see Design Criteria (web-base standard) - Part 3.4 the university Utilities Mechanical Infrastructure Guidelines/Considerations. Both the Design Criteria and the Construction Standards are co-equal in authority.

B. This applies to single stage or multi-stage evaporative cooling sections.

1.2 SYSTEM DESIGN REQUIREMENTS

A. The casing shall be constructed of reinforced stainless steel panels and shall be designed for front access to the pump, strainer, and float assembly. The top cover is to be hinged for service access to the media and spray distribution header. Dielectric gasketing shall be installed between the evaporative cooling section and other non-compatible metals which come in contact at wet surfaces.

B. The sump shall be 12 inches deep minimum, of 14-gauge stainless steel construction, with bleed, 2” overflow, and 2” drain connections for complete sump drainage. Sump shall extend 6” (min.) upstream of the media and shall be large enough to accommodate the pump(s) on the downstream side, but shall extend no less than 12” past the media.

C. Include adequately sized brass float valve assembly for makeup water control.

D. The sump shall be sloped to the drain outlet for complete drainage.

E. Provide a 12-inch deep pad of Munters Glasdek media. Maximum face velocity without water carryover shall be 500 fpm. Evaporative cooling effectiveness shall be 90% at 450 fpm face velocity. Evaporative media shall be installed per installation details for industrial evaporative coolers and humidifiers equipped for Glasdek media, engineering bulletin EB-ID1-0405 or latest standard

F. Media spray pump(s) shall be submersible type with stainless-steel inlet strainer. Pump motor(s) shall be thermally protected and capable of being operated dry for up to 12 hours without damage.

G. Provide factory-installed float switch to lock-out spray pumps until sump fill level is sufficient to submerge the pump inlet.

H. Pumps shall be sized to provide 2 GPM per square foot of top surface of the pad (2 GPM per linear foot for a 12-inch thick pad).

I. Piping and distribution header shall be Type L copper, with non-clogging spray distribution nozzles and hose-end blowdown valves on both ends of the unit. Provide with brass balancing valve and a brass bleed-off valve. The drain and fill valves shall be motorized, full-port ball valves, provided by the temperature control contractor. Valves shall conform to specification Section 23 05 23.

J. Construction shall conform to the Evaporative Cooling Module Piping and Construction Detail on the drawings and the design guidelines issued by the Munters Corporation.

K. Evaporative cooling media to be downstream of fan(s) and cooling coil(s).

L. Evaporative supply water shall be metered, with pulsed output to the BAS.
M. Provide conductivity monitor, monitored by the BAS to control bleed valve.

N. Provide common sump with equalizing tube.

O. All components in the evaporative cooling section shall be rust-proof.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TRAINING

A. Schedule a minimum of four (4) hours of training with the university. The manufacturer’s representative, and the Division 23 Contractor shall be present. The training shall be coordinated by the Division 23 Contractor and the university in conjunction with the other mechanical equipment on the project.

B. Train the university's maintenance personnel on start-up and shutdown procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the university's personnel, the contents of the Operating and Maintenance Data.

C. Schedule training with the university through the Architect/Engineer with at least seven (7) days prior notice.

END OF SECTION 23 76 00
SECTION 26 00 00 - ELECTRICAL

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Branch Circuit Requirements:
   1. Corridor receptacle circuits shall not be combined with office or laboratory receptacle circuits.
   2. Housekeeping receptacle circuits shall not be combined with office or laboratory receptacle circuits. Provide separate housekeeping receptacles in laboratory Linear Equipment Rooms, clearly identified by an Orange duplex receptacle.
   3. Offices shall have individual dedicated circuits as required for specific equipment. A maximum of 6 general purpose receptacles per 20A circuit is allowed.
   4. Connect Laboratory receptacles in “Multi Outlet Assembly” (MOA) to alternating circuits (i.e. A, B, C, A, B, C). A maximum of 4 receptacles per 20A circuit is allowed.
   5. Provide countertop receptacles in Laboratories with maximum two (2) foot on center spacing. Each outlet within 6 feet of a sink edge or water source shall be GFCI type. Protection via feed-thru GFI or GFCI breaker is not allowed.
   6. Provide general receptacles in corridors no further than 50’ apart.
   7. Laboratory freezers such as -80 degree Celsius or similar equipment shall be provide at minimum with a dedicated 120V, 20A single 5-20 receptacle or as required per equipment. All receptacles shall be RED and connected to an emergency circuit.
   8. Provide dedicated neutral conductors for all circuits.

B. Design Charette:
   1. Design team shall schedule a Design Charette with the University Project Manager and facilities group at 100% Design Development phase and 50% Construction Document phase.
   2. Charette shall include the following:
      a. Electrical power distribution, including service entrance, standby system, riser closet locations and layouts.
      b. Lighting design, including fixture layouts, egress lighting, fixture types, samples of specialty fixtures, accessibility for fixture maintenance and lighting controls.
      c. Fire alarm design, including occupancy type, sequence of operations and interface with security systems.

C. Surge Suppression:
   1. Provide integral Transient Voltage Surge Suppressors at the following locations:
      a. Main Service Switchboards and Switchgear
      b. Computer Laboratory Panel Boards
      c. Information Services Panel Boards.
      d. NMR Panelboards

D. Exterior Electrical Equipment:
   1. Provide 15’ minimum clearance around generators for maintenance access.
   2. Provide ventilation for primary switching and exterior substations. Maintain positive elevation for exterior electrical equipment to protect against wet weather.
   3. Provide exterior connections to a portable 500 kW generator for each building not provided with an emergency generator system. Provide kirk-key interlock for operation of generator system.

E. Provide a complete Lightning Protection System for each building.

F. Demolition:
   1. Demolish all devices, conduit, wiring and associated equipment which do not remain in a remodel.
   2. Completely remove all conduit, wiring, boxes, hangers, etc. back to the source.
3. Abandoned devices and equipment are not acceptable.
4. Recycle or dispose of all demolished items at a licensed facility.

G. Animal Facilities:
1. Provide redundant feeders to all distribution boards serving animal care facilities.
2. Provide 100% generator backup power for all systems serving the animal care facilities.
3. Provide all power and communication devices with weather proof covers. Mount devices at 42” AFF. Mount all devices in office areas at standard height without weather proof covers.
4. Provide cord reel centered in the ceiling between each row of cages.
5. Sharing power circuits between holding rooms is not acceptable.
6. Silicone seal all conduit wall penetrations. Internally seal all conduits after wiring has been pulled.
7. Provide emergency power off (EPO) capabilities for all branch feeders serving sterilizers. Locate EPO switch near the exit door, away from sterilizer.

H. Routing of electrical busway through chemical storage rooms is not acceptable.

I. Refer to Section 01 31 00 – Project Management and Coordination for additional details.

PART 2 - PRODUCTS

A. Not Applicable

PART 3 - EXECUTION

A. Not Applicable

END OF SECTION 26 00 00
SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

1.2 DEFINITIONS

A. Refer to Article 100 of the currently adopted National Electrical Code for definitions as applicable to this project.

B. Other definitions:
   1. "Concealed": Embedded in masonry, concrete or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.
   2. "Exposed": Not installed underground or "concealed" as defined above.
   3. "Furnish" or "Provide": To supply, install and connect up complete and ready for safe and regular operation of particular work unless specifically otherwise noted.
   4. "Install": To erect, mount and connect complete with related accessories.
   5. "Indicated", "Shown" or "Noted": As indicated, shown or noted on drawings or specifications.
   6. "Related Work" includes, but is not necessarily limited to, mentioned work associated with, or affected by, the work specified.
   7. "Reviewed", "Satisfactory", "Accepted", or "Directed": As reviewed, satisfactory, accepted, or directed by or to Engineer.
   9. "Supply": To purchase, procure, acquire and deliver complete with related accessories.
   10. "Wiring": Raceway, fittings, wire, boxes and related items.

1.3 SUBMITTALS

A. Submittals shall be made in accordance with General Conditions of Contract and the requirements of Section 01 33 00.

B. Shop drawings shall include equipment catalog cuts or manufacturer's printed data identifying: dimensions, weights, recess openings, equipment arrangements, electrical characteristics with bus size, electrical rating, material, wiring diagrams indicating circuit arrangement and NEMA rating for, but not limited to the following:
   1. Medium voltage distribution equipment, cable and devices (13.2 kv and above)
   2. Low-Voltage Transformers
   3. Switchboards
   4. Panel boards
   5. Motor Control Centers
   6. Enclosed Switches and Circuit Breakers
   7. Network Lighting Controls
   8. Automatic Transfer Switches
   9. UPS Equipment
   10. Contactors
   11. Wiring Devices
   12. Interior and Exterior Lighting
   13. Hangers and Supports for Electrical Systems
   14. Grounding and Bonding
   15. Multi-Outlet Assemblies
   16. Generators
   17. Modular Wiring Systems
18. Electrical Systems Control  
19. Fire Detection and Alarm  
20. Communication Systems  
21. Lightning Protection System  
22. Electronic Meters  

C. Submittals shall also include ¼” scale layouts of all electrical rooms, telecom rooms, fire alarm rooms and generator rooms. Include all equipment sizes and clearances.  

D. Submit composite coordination drawings to include location and routing of the electrical system components in relation to the mechanical ducts, piping and structural beams.  

1.4 QUALITY ASSURANCE  

A. Installer Qualifications: All electrical work at the University shall be performed by a State of Colorado licensed contractor under the supervision of a licensed electrician. Contractors shall verify that electricians are currently licensed by the State of Colorado and shall supply Project Manager with names and license numbers. Contractor shall have a minimum of 3 years of satisfactory performance in conducting the type of work specified.  
   3. NECA - Standard of Installation.  
   5. IEEE – The Institute of Electrical and Electronics Engineers.  
   7. The University/Anschutz Medical Campus Project Guidelines and Standards.  
   8. International Building Code in accordance with the Campus Building Official.  
   9. ASTM - American Society of Testing Materials  
   10. IPCEA - Insulated Power Cable Engineers Association  
   11. Underwriter's Laboratories (UL)  
   12. American National Standards Institute (ANSI)  
   13. Other requirements as listed elsewhere in these specifications.  

B. The drawings and specifications take precedence when they are more stringent than codes, statutes, or ordinances in effect. Applicable codes, ordinances, standards and statutes take precedence when they are more stringent than, or conflict with the drawings and specifications.  

C. Record Documents:  
   1. Maintain a separate set of contract electrical drawings at the site in accordance with Section 01 74 00 to show the following:  
      a. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.  
      b. All branch circuits, feeders, communications conduits embedded in concrete, dimensioned from prominent building lines.  
      c. Equipment locations (exposed and concealed) dimensioned from prominent building lines.  
      d. Approved substitutions, Contract Modifications, and actual equipment and materials installed.  

D. Operations and Maintenance Data:  
   1. O and M Data shall be provided in accordance with Section 01 78 23 including the following information:  
      a. Description of function, normal operating characteristics and limitations, fuse curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
b. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

c. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

d. Servicing instructions and lubrication charts and schedules.

e. Complete list of parts and wiring diagrams.

f. Names, addresses and telephone numbers of the Contractor, Sub-contractors and local company responsible for maintenance of each system or piece of equipment.

g. All information shall be permanently bound in a 3-ring binder. The job name and address, and Contractor's name and address shall be placed on the cover and spine of each binder in a permanent manner. Dymo-tape is not acceptable.

h. Copies of all test reports shall be included in the manuals.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in accordance with manufacturer's instructions, and the requirements of Section 01 10 00.

1.6 WARRANTY

A. All electrical equipment, materials and workmanship warranties shall be provided in accordance with the requirements of Section 01 78 36 and the following:

1. The Contractor warrants the electrical system, material and workmanship, for a period of one year from the date of the University final acceptance of the installation unless as otherwise noted in Commissioning.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. All equipment and materials installed shall be new, unless otherwise specified. Defective or damaged materials shall be replaced or repaired, prior to final acceptance, in a manner acceptable to the Engineer or The university and at no additional cost to the University.

B. All electrical materials shall be acceptable for installation only if labeled or listed UL and, if accepted, by the authority having jurisdiction.

C. All major equipment components shall have the manufacturer's name, address, model number, and serial number permanently attached in a conspicuous location.

D. Fire Seals:

1. Material: Fire stopping material shall be asbestos free, 100% intumescent, have code approval under BOCA, ICBO, SSBC, NFPA 101, NFPA 70, and be capable of maintaining an effective barrier against flame and gases in compliance with the following requirements.

2. Flame Spread: 25 or less, ASTM E84

3. Fire Resistance and Hose Stream Tests: Fire stopping materials shall be rated “F” and “T” in accordance with ASTM E 814 or UL 1479. Rating periods shall conform to the following:

| (F) | 3 | (T) | 3 | Time-rated floor or wall assemblies. |
| (F) | 3 | (T) | 3 | Openings between floor slabs & curtain wall. |

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
A. Construct Work in sequence under provisions of Division 1 where applicable.

B. Electrical Contractor shall coordinate Divisions 26, 27, and 28 work with the installer of Division 21, 22 and 23 and other work to ensure that code required clearances relating to space required for access to electrical equipment is properly maintained.

C. Install Work using procedures defined in NECA Standard of Installation.

D. Workmanship shall conform to highest industry standards for each trade involved in installation of the Work.

E. Upon completion of work, all equipment and materials shall be installed complete, thoroughly checked, correctly adjusted, and left ready for intended use or operation. All work shall be thoroughly cleaned and all residues shall be removed from surfaces.

F. Exterior surfaces of all material and equipment shall be delivered in a perfect, unblemished condition.

G. Carefully lay out all work in advance so as to eliminate where possible, cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings and roofs. Any damage to the building, structure, piping, ducts, equipment or any defaced finish shall be repaired by skilled mechanics of the trades involved at no additional cost to the University.

H. All openings made in fire-rated walls, floors, or ceilings shall be patched and made tight in a manner to conform to the fire rating for the surface penetrated. Paint to match surface when visible.

I. All penetrations required through completed concrete construction shall be core drilled at minimum size required. Precautions shall be taken when drilling to prevent damage to structural concrete. The Contractor shall obtain permission from the Architect and Structural engineer before proceeding with drilling.

J. Sleeve Seals: Provide sleeve seals for penetrations located in foundation walls below grade, or in exterior walls, of one of the following:
   1. Caulk between sleeve and raceway with approved Caulk material.
   2. Mechanical Sleeve Seals: Modular mechanical type, as manufactured by Thunder line Corp., consisting of interlocking synthetic rubber links shaped to continuously fill annular space between raceway and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal.

K. Install equipment and materials to provide required Code clearances and access for servicing and maintenance. Coordinate the final location with piping, ducts, and equipment of other trades to insure proper access for all trades. Coordinate locations of concealed equipment, disconnects, and boxes with access panels and doors. Allow ample space for removal of parts, fuses, lamps, etc., that require replacement or servicing according to the National Electric code and the AHJ.

L. Extend all conduits so that junction and pull boxes are in accessible locations.

M. Install access panel or doors where equipment or boxes are concealed behind finished surfaces in areas such as restrooms. These access doors shall be a minimum of twenty by twenty inches or as required to accommodate full pull box or equipment access.

N. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
O. Electrical system layouts indicated on drawings are generally diagrammatic but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from engineering drawings.

P. Consult all other drawings. Verify all scales and report any dimensional discrepancies or other conflicts to Engineer before submitting bid.

Q. All home runs to panel boards are indicated as starting from outlet nearest panel and continuing in general direction of that panel. Continue such circuits to panel as though routes were completely indicated.

R. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc. required for equipment specified under this Division.

S. Remove all unused or abandoned conduit, junction boxes, panels, and other electrical components back to the source.

T. Provide GFCI type receptacles for all "above counter" receptacles located within 6' of any sink or basin.

U. Provide GFCI type receptacles for receptacles located with 6' of any eyewash station.

V. Clean all luminaries, lamps and lenses prior to final acceptance. Replace all inoperative lamps.

W. Provide all power feeds and final connections to motors and other electric equipment furnished under Divisions 21, 22, and 23.
   1. Install and wire through all control devices which directly handle full load motor or electric heating equipment current, such as magnetic starters, line voltage thermostats, P.E. switches, etc. which are furnished by Electrical Contractor. Located where shown on the electrical drawings.
   2. Provide disconnects for all mechanical equipment as indicated on project drawings.
   3. Provide all power and control wiring which directly handles full load current of motors or electric heating equipment.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Operating and Acceptance Tests: Provide all labor, instruments, and equipment for the performance of tests as specified below and elsewhere in these specifications.
   1. Perform a careful inspection of the main switchboard bus structure and cable connections to verify that all connections are mechanically and electrically tight.
   2. For a one-day period after the remodeled area has been placed into normal service, record the full load current in each phase or each line at the panel bus and submit to the Engineer.

B. Test Reports:
   1. Test Reports: Submit three (3) copies of test results.
   2. The final University inspection of the project will not be made until a satisfactory report is received and approved by the University Project Manager.
   3. Results shall include:
      a. Insulation resistance readings for each segment of high voltage (over 600V) cable, each phase.
      b. Insulation resistance readings for transformers for each phase of primary and secondary to ground and for primary to secondary.
      c. Insulation resistance readings on all feeders entering main distribution switchboard, each phase.
      d. Resistance to ground readings for main distribution switchboard service ground.
      e. Insulation resistance readings for all motors and motor feeders 5 horsepower or greater.
      f. Full load current reading for main service entrance and main distribution panel board, each phase.
4. Testing shall be done by an independent testing agency.

C. Clean-Up: Remove all materials, scrap, etc., relative to the electrical installation, and leave the premises and all equipment, lamps, fixtures, etc. in a clean, orderly condition. Any costs to the University for clean up of the site will be charged against the Contractor.

3.3 COMMISSIONING (DEMONSTRATION)

A. Acceptance Demonstration: Upon completion of the work, at a time to be designated, the Contractor shall demonstrate for the University the operation of the entire installation, including all systems provided under this contract.

B. The Contractor shall furnish the services of a qualified representative of the supplier of each item or system who shall instruct specific personnel, as designated by the University, in the operation and maintenance of that item or system.

1. Instruction shall be given when the particular system is complete, and shall be of the number of hours indicated. A representative of the Contractor shall be present for all demonstrations.

END OF SECTION 26 05 00
SECTION 26 05 13 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Provide complete wire and cable system to meet the requirements of the project.

B. Provide wire size in accordance with NEC.

PART 2 - PRODUCTS

2.1 MEDIUM VOLTAGE CABLES

A. Provide single copper conductor shielded power cable insulated with ethylene propylene rubber (EPR) rated for 133% insulation level, insulation thickness at 220 mils. The cable shall have a continuous temperature rating of 90°C, an emergency overload temperature rating of 130°C, and a short-circuit temperature rating of 250°C. The cable shall be suitable for operation in wet or dry locations and for installation in duct or conduit. The cable shall be listed as Type MV-90, 15KV XLP-PVC and shall carry a UL label.

B. Insulation shield shall be semi-conducting extruded, semi-conducting EPR, and uncoated copper tape. Shield ampacity shall be equivalent to one overlapped 5 mil copper tape (with a 12.5% (mini-overlap)). Jacket thickness shall not be less than 80 mils, of black polyvinyl chlorides.

C. Termination shall be Class 1 or Class 2; of the molded elastomer, wet-process porcelain, pre-stretched elastomer, cold shrink elastomer, or taped type. Class 3 terminations are not acceptable.

D. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Connectors shall be of suitable construction for the application and type of cable connected, and shall include cable shield adapters.

PART 3 - EXECUTION

3.1 WIRE

A. Install all above grade medium voltage cable in rigid metallic conduit unless noted otherwise.

B. A wire pulling lubricant must be used when pulling conductors through conduit or duct runs over 10 feet in length. The pulling compound shall be compatible with the raceway, conductor and jacket material.

C. Cable splices and joints shall be allowed only in pull boxes. Notify facilities management prior to splicing cables. Identify all splices and pull box locations on as-built drawings.

D. Ground conductors shall be installed in the same duct with their associated phase conductors.

E. Wires shall be pulled in using pulling eyes securely attached to the conductor. Pulling grips which transmit the pulling tension directly to the jacket or insulation shall not be permitted.

3.2 JOINTS AND SPLICES

A. Joints and splices shall be performed based on the manufacturers’ written instructions.
B. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shield may be integrally molded parts of preformed joints. Shields shall be grounded at each joint.

3.3 TERMINATIONS

A. Terminations shall be of the type required for equipment termination, and shall be performed based on the manufacturer’s written instructions.

B. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding.

3.4 FIELD QUALITY CONTROL

A. Inspect exposed cable sections for damage after cable is pulled.
   1. Material: Contractor shall provide all necessary testing equipment and devices required to perform the tests described in this Section.

B. Perform DC high potential tests per manufacture recommendations.

C. Perform shield continuity tests. Investigate resistance values in excess at 10 ohms per 1000 ft.

3.5 EXECUTION

A. Insulation Resistance (Megger) Testing
   1. This procedure will provide the necessary guidelines to ensure an acceptable insulation resistance test.
      a. This procedure is applicable to Megger testing only.
      b. Megger testing shall be done during both construction and start-up.
      c. This procedure applies to the following equipment:
         1) Medium Voltage Switchgear.
         2) Medium Voltage Cable.
   2. In all cases, the manufacturer’s instructions shall be consulted and integrated into this test guideline to assure full compliance and acceptance without jeopardizing equipment warranties.
   3. Test Preparation:
      a. Verify that proper Megger apparatus of the correct voltage is available.
      b. Equipment to be tested shall be clean and dry.
      c. All equipment shall be tested before being initially energized. All necessary precautions shall be taken to prevent the equipment from becoming energized during the test.
      d. Except as required for testing, all construction related to the equipment shall be finished.
      e. Ensure equipment frame grounds are complete.
   4. Test Procedure:
      a. Voltage shall be applied as quickly as possible.
      b. After each test, the equipment shall be adequately grounded to remove any residual charge.
      c. Equipment shall be tested both phase to phase and phase to ground where applicable.
      d. Medium voltage 15KV cables shall be tested twice.
         1) After pulling but before termination, all cables shall be tested just prior to termination to determine if any damage occurred during pulling.
         2) After termination, medium voltage cables shall be tested just prior to being energized, as part of the system including the intended load.
   5. Test Acceptance:
      a. The tests shall be considered satisfactory on the equipment being tested if all recorded readings meet the manufacturers’ acceptance criteria.

3.6 DIRECT CURRENT OVERPOTENTIAL TEST
A. This test procedure will provide the necessary guidelines to accomplish an acceptable insulation overpotential test.
   1. This procedure is applicable to cable rated for 5KV and larger.
   2. Test prior to permanent termination and energizing.

B. In all cases the manufacturer’s instructions shall be consulted and integrated into this procedure to assure compliance and acceptance without jeopardizing equipment warranties.

C. Preparation:
   1. Take necessary steps to insure that equipment will not become energized during the test.
   2. Appropriate D.C. hi-pot equipment is available and the user has 3 years experience testing medium voltage cable and equipment.
   3. The equipment to be tested has successfully passed an insulation resistance test (Megger) immediately prior to this test.

D. Testing – Step Method
   1. Apply test voltage in 7 equal increments recording leakage at each step and stabilize.
   2. Hold maximum test voltage for 10 minutes.

END OF SECTION 26 05 13
SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Provide complete wire and cable system to meet the requirements of the project. Provide wire sizes in accordance with NEC.

1.2 SUBMITTALS

A. Product data shall be submitted for in accordance with the requirements of Section 26 05 00 each of the following:
   1. Wires
   2. Cables
   3. Connectors

1.3 QUALITY ASSURANCE

A. Wire and cable shall be provided and installed in accordance with the requirements of Section 26 05 00.

B. Installer Qualifications and Certifications: Firms with at least 3 years of successful installation experience with projects utilizing electrical wiring cabling work similar to that required for this project.

C. Regulatory Requirements: Conform to applicable code relations regarding toxicity of combustion products of insulating materials

D. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable products of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Wire and cable shall be delivered, stored and handled in accordance with the requirements of Section 26 05 00.

B. Deliver wire and cable properly packaged in factory-fabricated type containers, or wound on NEMA-specified type wire and cable reels.

C. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

D. Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.5 WARRANTY

A. Wire and cable warranties shall be provided in accordance with the requirements of Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following (for each type of wire, cable, and connector):
   1. Wire and cable:
      a. Triangle - PWC
      b. American Wire and Cable Co.
      c. Anaconda-Ericsson Inc; Wire and Cable Div.
      d. Belden Div; Cooper Industries
      e. General Cable Corporation
      f. General Electric
      g. Okonite
   2. Connectors:
      a. O-Z/Gedney Co.
      b. AMP, Inc.
      c. Burndy Corporation
      d. Ideal Industries, Inc.
      e. 3M Company
      f. Thomas and Betts Corp.

2.2 MATERIALS, GENERAL

A. Wires and Cables:
   1. Provide new wire and cable suitable for the temperature, conditions, and location where installed. All cable shall be new and shall conform to or exceed IPCEA requirements. Building wire shall be insulated with THHN/THWN/THW or XHHW insulation, rated 600 volt.
   2. Conductors: Provide solid conductors for power and lighting circuits 12 AWG and smaller. Provide stranded conductors for 10 AWG THHN/THWN and larger. In sizes 250 MCM and larger use type THW or THWN. In sizes #1 AWG and smaller all conductors shall have heat/moisture resistant thermoplastic insulation type THW or THWN (75 degree C), except as follows:
      a. Where conduit temperature will exceed 100 degree F, use type THHN (90 degree C). Type XHHW (90 degree C) permissible in dry locations.
      b. In 120-volt incandescent fixtures, type AF (150 degree C).
      c. In wire ways of fluorescent lighting fixtures types THW-MTW, THHN (90 degree C).
   3. Conductor Material: Provide copper for all wires and cables.
   4. Metal Clad cable is acceptable.
   5. Use colors of wires as specified in paragraph 3.5 of this section.
   6. For general applications, other than special use, use THHN insulated wire.
   7. Type NM, NMC, NMS cable are not acceptable for any application.
   8. Use copper wire only.
   9. No wire splices shall be allowed in the conduit or conduit fittings. All splices shall be done in an approved box.
   10. Grounding conductors shall be copper type THHN with green integrally-colored insulation, sized to meet NEC.
   11. Plenum rated cable when required by Plenum conditions.

B. Connectors:
   1. Provide UL type factory-fabricated, solder less metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperatures equal to or greater than those of the wires upon which used.

C. Wiring to Light Fixtures:
   1. Type THHN to fluorescent light fixtures, 12-gauge minimum.
   2. Type THHN to incandescent fixtures, 12-gauge minimum.

D. Wire Connectors:
   1. For wires size #8 AWG and smaller, insulated pressure type (with live spring) rated 105 degree C, 600 volt, for building wiring and 1000 volt in signs or fixtures. 3M or Ideal.
2. For wires size #6 AWG and larger, T & B or equivalent compression type with 3M #33 or #88 tape insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that mechanical work likely to damage cable has been completed.

3.2 INSTALLATION, GENERAL

A. Install electrical cables, wires and connectors in compliance with applicable requirements of NEC, NEMA, UL, and NECA’s “Standard of Installation”, and in accordance with recognized industry practices.

B. Coordinate wire/cable installation work, including electrical raceway and equipment connection work, with other work. Pull no wire into any portion of conduit system until all construction work, which might damage the wire, has been completed.

C. BAS Conductor installation: (see Section 23 09 13)

D. Wires and Cables:
   1. On systems greater than 600V thoroughly swab raceway before installing wire. Pull conductors simultaneously where more than one is being installed in same raceway. Use pulling compound or lubricant on all cable installations. compound used shall not deteriorate conductor or insulation.
   2. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway. Do not use rope hitches for pulling attachment to wire or cable. Do not exceed manufacturer's tension requirements.
   3. Keep conductor splices to minimum. Install all wire continuous from outlet to outlet or terminal to terminal. Splices in cables when required shall be made in hand holes, pull boxes, or junction boxes and shall be in strict accordance with cable manufacturer’s recommendations utilizing solder less connectors NEMA/UL approved for the use. Splice only in accessible junction boxes. Use splices and tap connectors which are compatible with conductor material.
   4. Install splices and tapes, which possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
   5. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer’s published torque tightening values. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486 for copper.
   6. Support cables above accessible ceilings, do not rest on ceiling tiles. Use spring clips and hanger rods, bridle rings or ‘J’ hooks, independent from the ceiling suspension system to support cables from structure.
   7. Provide adequate length of conductors within electrical enclosures and form the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than 10 AWG cables to individual circuits. Make terminations so there is no bare conductor at the terminal.
   8. Make up splices in outlet boxes with 8-inch minimum of correctly color-coded tails left in box. Splices in wires size #8 AWG and smaller shall be made with insulated spring type wire connectors, "Scotchlok" or equivalent. Splices in larger wire and cables shall be made with indent connectors NEMA/UL approved for the purpose.
   9. Use split bolt connectors for copper wire splices and taps, 6 AWG through 1 AWG. Tape un-insulated conductors and connectors with electrical tape to 150% of the insulation value of conductor. Rubber, friction and 3M-33 or 88 or better. Two (2) layers minimum each.
   10. Use copper compression connectors for copper wire splices and taps, 1/O AWG and larger. Tape un-insulated conductors and connectors with electrical tape to 150% of the insulation value of the conductor. Rubber, friction and 3M-33 or 88.
11. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.
12. Thoroughly tape the ends of spare conductors in boxes and cabinets.
13. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural member, and follow surface contours, where possible.
14. Make all ground, neutral and line connections to receptacle and wiring device terminals as recommended by manufacturer. Provide ground jumper from outlet box to individual ground terminal of devices.
15. Parallel conductors shall be cut to the same length and be the same type of wire.
16. All splices in control panels, terminal junction boxes, low voltage control circuits and fire alarm conductors shall be on numbered terminal strip.
17. When routed in a wall, install all thermostat wire, fire alarm, computer cable, low voltage cable, and other communication cable in conduit.
18. All junction boxes shall be fully accessible.
19. All wiring shall be routed through an acceptable raceway regardless of voltage application, unless specified otherwise under other sections of these standards.

3.3 TESTING, CLEANING AND CERTIFICATION

A. Refer to Section 26 05 00 for testing, cleaning, and certification requirements.
B. Prior to energizing circuitry, check installed wires and cables with megaohm meter to determine insulation resistance levels to ensure requirements are fulfilled. Test shall be made on all feeders regardless of size and on all branch circuits with No. 4 AWG and larger conductors.
C. Prior to energizing, test wires and cables for electrical continuity and for short-circuits.
D. Subsequent to wire and cable hook-up, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

3.4 COMMISSIONING (DEMONSTRATION)

3.5 SCHEDULES

A. Color code secondary service, feeder, and branch circuit conductors as follows:

<table>
<thead>
<tr>
<th>120/208 Volts</th>
<th>Phase</th>
<th>277/480 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>Brown</td>
</tr>
<tr>
<td>Red</td>
<td>B</td>
<td>Orange</td>
</tr>
<tr>
<td>Blue</td>
<td>C</td>
<td>Yellow</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>Gray</td>
</tr>
<tr>
<td>Green</td>
<td>Ground</td>
<td>Green</td>
</tr>
<tr>
<td>Switch leg - Pink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 &amp; 4 way travelers - Purple</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Conductors shall be solid color for entire length.

C. EXCEPTION:
   1. Conductors 8 AWG and larger may be black and shall be with color-coded at each termination and in each box or enclosure. For a distance of 6 inches use half-lapped 3/4 inch plastic tape in the specified color. Do not cover cable identification markings. Adjust tape locations to prevent covering of markings.

END OF SECTION 26 05 19
SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Ground the electrical service system neutral at service entrance equipment to grounding electrode system: cold water service pipe, building steel, concrete encased electrode and supplementary grounding electrodes in compliance with NEC.

B. Ground each separately derived system neutral to nearest metallic cold water pipe, 2” diameter or larger, building steel or the referenced ground bar as shown on drawings.

C. Provide grounding for telecommunications systems in accordance with the requirements in Section 27 05 26 Ground and Bonding for Communications Systems. Minimum conductor size between ground bar 3/0.

D. Interconnect all ground bars in the building.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Provide a separate insulated equipment-grounding conductor in all feeders. Terminate each ground conductor to the bushing and ground lug.

B. All grounding materials shall be copper with the exception of ground rod, which may be copper clad steel.

C. Grounding and Bonding for Communications Systems. Provide code-sized ground cable bonding jumpers, installed with ground clamps, across all conduit expansion couplings and fittings.

D. Provide a corrosion-resistant finish to field connections, buried metallic bonding products, and where factory applied protective coatings have been destroyed, where subject to corrosive action.

E. All continuous runs of cable tray and all isolated sections of cable tray shall be grounded at intervals not to exceed 20 feet.

F. Provide an equipment-grounding conductor in all nonmetallic and flexible conduits.

G. Provide equipment-grounding conductor in all branch circuits. Route to switches, receptacles, equipment enclosures, equipment, and panels etc. and ground as required.

H. Use mechanical grounding connectors for all grounding connections. Exothermic welded connections may be used underground or to building steel.

I. Minimum ground resistance:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Earth Ground Resistance to Equipment (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pad Mount Transformer</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Secondary neutrals and other ground</td>
<td>10</td>
</tr>
<tr>
<td>Lightning protection grounds</td>
<td>5</td>
</tr>
</tbody>
</table>

J. Provide a separate insulated equipment-grounding conductor in feeder and branch circuits. Terminate each end on a grounding lug, buss or bushing.

K. Provide grounding bushings and bonding jumpers for all conduits terminating in reducing washers, concentric, eccentric or oversized knockouts at panel boards, cabinets, and gutters.

L. Provide bonding wire in all flexible conduits.

END OF SECTION 26 05 26
SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Provide equipment supports rated for the supported loads.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Conduit Hangers: Galvanized steel with special accessories for purpose and adequate to support load imposed.

B. Coatings: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance-using NEMA/UL approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

C. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, and wall brackets.

D. Fasteners: Types, materials, and construction features as follows:
   1. Expansion Anchors: Carbon steel wedge or sleeve type.
   2. Toggle Bolts: All steel springhead type.

E. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for no armored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

G. U-Channel Systems: 16-gauge steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

H. Supports: Provide supporting devices of types, sizes and materials indicated; and having the following construction features:
   1. One-Hole Conduit Straps or Minerallac: For supporting 3/4 inch and smaller conduit, galvanized steel.
   2. Two-Hole Conduit Straps or Minerallac or industry approved equal: For supporting 1 inch and larger conduit, galvanized steel; 3/4 inch strap width; and 2-1/8 inch between center of screw holes.

I. Fabricated Supporting Devices:
   1. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.
   2. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.
3. Pipe Sleeves: Provide pipe sleeves of one of the following:
a. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snap lock joint, welded spiral seams, or welded longitudinal joint.
b. Fabricate sleeves from the following gauge metal for sleeve diameter noted:
   1) 3-inch and Smaller: 20 gauge
   2) 4-inch to 6-inch: 16 gauge
   3) Over 6-inch: 15 gauge
c. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
d. EMT, IMC, or Rigid Conduit.

J. J-Hooks and Bridle Rings
1. J-hooks and bridle rings maybe used to support low voltage wiring systems.

K. The following are prohibited.
1. Plastic or fiber anchors.
2. Drilling or structured steel members.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Conduit Hangers: Support individual conduit 1-1/2 inch and larger and all multiple conduit runs with hangers. Clamp conduits individually to each support.

B. Supports and Hangers:
1. Support and align all raceways, cabinets, boxes, fixtures, etc., in an accepted manner and as herein specified. Support raceways on accepted types of wall brackets, specialty steel clips or hangers, ceiling trapeze hangers or malleable iron straps. Provide lead expansion shields in concrete, machine screws, bolts or welding on metal surfaces, and wood screws on wood construction. Use of powder-driven studs is prohibited without express permission from the University Project Manager.
   a. Mount all conduits to structure a minimum of 7 inches above any accessible type ceiling, or with spacing as required to permit relocation of recessed fixtures to any location.
2. Structural and post tensioned concrete members shall not be drilled or pierced without prior approval from the University Project Manager.
3. Where outlets are installed in steel stud type systems, provide additional cross bracing, bridging and/or straps as required to make outlet completely rigid prior to application of wall facing material.
4. Design hangers and wall brackets so that maximum deflection will be no greater than 1/8 inch.
5. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
6. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
1. Conform to manufacturer’s recommendations for selection and installation of supports.
2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
4. Use of ceiling support wires is unacceptable.
5. Support parallel runs of horizontal raceways together on trapeze-type hangers. Use 3/8-inch diameter or larger threaded steel rods for support. Threaded rod shall be covered by % inch conduit from bottom of (trapeze) support to 6-inches above cable tray.
6. Support individual horizontal raceways by separate pipe hangers.
7. Space supports for raceways in accordance with NEC.
8. In all runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
9. Threaded rod supports to have bottoms cut off at a maximum length equal to rod diameter below bottom double nut. Remove sharp edges.

D. Miscellaneous Supports: Support miscellaneous electrical components separately and as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panel boards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

E. In open overhead spaces, support metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an engineer approved type of fastener not more than 24 inches from the box.

F. Sleeves: Install in walls and all other fire-rated floors and walls for raceways and cable installations as required. Where sleeves through floors are installed, extend above finish floor. For sleeves through fire rated-wall or floor construction, apply UL listed fire stopping sealant in gaps between sleeves and enclosed conduits and cables. See Engineering plans for location and extent of fire rated assemblies.

G. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, bus ways, cabinets, panel boards, transformers, boxes, disconnect switches, and control components in accordance with the following:
   1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Powder-driven studs are not acceptable. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
   2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
   3. Ensure that the load applied to any fastener does not exceed 25% of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

H. Telecommunications Systems Cable Supports: Use cable tray or telecommunications approved cable supports.

END OF SECTION 26 05 29
SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESIGN REQUIREMENTS

A. Provide complete raceway system required to meet project requirements in sizes as required by NEC.

B. Utilize boxes as part of the electrical raceway system. Size boxes in accordance with NEC requirements and this standard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Conduit: Allied
   a. Republic
   b. Carlon

2. Fittings and Bodies:
   a. O/Z Gedney
   b. Regal was purchased by Bridgeport
   c. Bridgeport
   d. Raco
   e. Appleton

3. Conduit Seals:
   a. Chase-Foam CTC PR-855, or approved equal

4. Wire ways:
   a. Hinged cover or screw cover complete with all necessary fittings which shall be of one manufacturer.

2.2 MATERIALS, GENERAL

A. Metal Conduit and Tubing:

1. Galvanized Steel Rigid Conduit (GRC):
   a. Conduit: Provide rigid steel conduit, hot-dipped galvanized with threaded ends Fittings: Threaded galvanized steel, bushings shall have nylon-insulated throat.

2. Electrical Metallic Tubing (EMT):
   a. Conduit: Galvanized steel tubing, galvanized on the outside and coated on the inside with a hard smooth lacquer finish. Fittings: Steel compression fittings for rain-tight and concrete-tight applications. Steel set-screw for interior connections. Set-screw quick fit type for 2-1/2 inch and larger may be used. Bushings shall be threaded and have nylon insulated throat or nylon bushing.

3. Intermediate metal conduit (IMC)
   a. Conduit: Provide intermediate steel conduit hot-dipped galvanized Fittings: Threaded galvanized steel, bushings shall have nylon-insulated throat.

4. Rigid Aluminum Conduit:
   a. Not allowed unless otherwise noted.

5. Flexible Metal Conduit:
   a. Conduit: Continuous spiral wound, interlocked, zinc-coated steel, NEMA/UL approved for grounding.
   b. Fittings: Cadmium plated, malleable iron. Straight connector shall be one-piece body, female end with clamp and deep slotted machine screw for securing conduit, and threaded male end provided with a locknut. Angle connectors shall be two-piece body with...
removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and threaded male end provided with a locknut. All fittings 1 inch and larger shall be terminated with threaded bushings having nylon insulated throats.

c. Maximum length of 6 feet.
d. Minimum size of 1/2 inch.

6. Liquid-Tight Flexible Metal Conduit:
   a. Conduit: Continuous spiral wound, interlocked zinc-coated steel with polyvinyl chloride (PVC) jacket, NEMA/UL approved for grounding.
   b. Fittings: Cadmium plated malleable iron. Straight and angle connectors shall be the same as used with flexible metal conduit but shall be provided with a compression type steel ferrule and neoprene gasket sealing rings.

7. Non-metallic Rigid Conduit
   a. PVC plastic schedule 40

B. Conduit Bodies:
   1. General: Types, shapes and sizes, as required to suit individual applications and National Electric Code (NEC) requirements. Provide matching gasket covers secured with corrosion-resistant screws.
   2. Metallic Conduit and Tubing: Use metal conduit bodies. Use bodies with threaded hubs for threaded raceways and in hazardous locations.
   3. Telephone EL’s are not acceptable.

2.3 MATERIALS, GENERAL

A. Sheet Steel: Flat rolled, code-gage, galvanized steel.

B. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.

C. Fasteners for damp or wet locations: Stainless steel screws and hardware.

D. Exterior Finish: Gray baked enamel for items exposed in finished locations except as otherwise indicated.

E. Metal outlet, device, and small wiring boxes:
   1. General: Boxes shall be of type, shape, size, and depth to suit each location and application.
   2. Steel Boxes: Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.

F. Outlet Boxes, Pull and Junction Boxes (J-Boxes):
   1. General: Boxes shall have screwed or bolted-on covers of material same as box and shall be of size and shape to suit application.
   2. Steel Boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.
   3. Hot dipped galvanized steel boxes: Sheet steel with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.
   4. Outlet Boxes: Hot-dipped galvanized of required size, 4 inch square, 2” depth minimum or octagonal and of depth required for flush mounted devices and lighting fixtures. Cast-type with gasketed covers for surface-mounted devices. All outlets for exterior application shall be cast, weatherproof type with gasket and cast cover plate.
   5. Junction and Pull Boxes: Use outlet boxes as J-boxes wherever possible. Larger J-boxes pull boxes shall be accessible and shall be fabricated from sheet steel, sized according to code.

G. Non metallic boxes are not permitted.
PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Conduit Sizes:
   1. The conduit shall be sized in accordance with NEC.
      a. For power and lighting circuits, the minimum conduit size shall be 3/4”
      b. Flexible and Liquid-tight Flexible Conduit: 1/2 inch for all runs. Maximum 6-foot length.
      c. Conduits used for home runs shall contain only the conductors for the circuits indicated on
         the drawings. Combining unrelated multiple home runs into a single conduit would not be
         permitted.

B. Type of Conduit Used
   1. Rigid Galvanized conduit or intermediate metallic steel conduit shall be installed in the following
      areas.
      a. All outdoor non-conditioned locations concealed and exposed.
      b. Interior exposed. Below 10 feet to floor. PVC coated 90 degree elbows underground when
         penetrating floor slabs.
   2. Electrical Metallic Tubing (EMT):
      a. Interior concealed spaces.
      b. Interior exposed above 10 feet to floor.
      c. Not permitted underground, in concrete, and in hazardous or corrosive areas.
   3. Sealtite metal conduit shall be provided for: Makeup of motor, transformer or equipment, and/or
      raceway connections where isolation of sound and vibration transmission is required. For
      connections in locations exposed to weather, or in interior locations subject to moisture, watertight
      flexible conduit shall be used.
   4. Non-metallic Rigid Conduit:
      a. In concrete and underground.
      b. Not permitted for interior use.

C. General: Install electrical raceway in accordance with manufacturer’s written installation instructions,
   applicable requirements of NEC, and as follows:
   1. Conceal all conduits unless indicated otherwise, within finished walls, ceilings, and floors. Keep
      raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes.
   2. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam
      piping, keep close to structure.
   3. Complete installation of electrical raceways before starting installation of conductors within
      raceways.
   4. Provide supports for raceways as required per NEC. Prevent foreign matter from entering
      raceways by using temporary closure protection.
   5. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise
      indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel. All
      bends shall be made in an approved bending machine or factory-made. Hickey bends will not be
      permitted in conduits larger than 3/4 inch. Refer to Section 27 05 28 for special bending
      requirements for Telecommunications Systems.
   6. Use raceway fittings that are of types compatible with the associated raceway and suitable for the
      use and location. Install expansion fittings across all structural construction joints and
      expansion/deflection couplings across all structural expansion joints and in every 200 feet of linear
      conduit run. A flexible bonding jumper at least three times the nominal width of the joint shall be
      installed.
   7. Run concealed raceways parallel and perpendicular to building elements at right angles.
   8. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and
      follow the surface contours as much as practical. Paint all exposed raceways to match surrounding
      area.
9. Run exposed and parallel raceways together. Make bends in parallel runs from the same centerline so that the bends are parallel. Factory elbows may be used only where they can be installed parallel. In other cases, provide field bends for parallel raceways.

10. Make raceway joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Joints in non-metallic conduits shall be made with solvent cement in strict accordance with manufacturer’s recommendations.

11. Termini: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. RGC shall be secured with double locknuts and an insulated metallic bushing. EMT shall be secured with one locknut and shall have nylon-insulated throats or threaded nylon bushings from 1/2 inch to 1 inch. 1-1/4 inch and above shall be metal with nylon insulated throats. Use grounding type bushings for feeder conduits at switchboards, panel boards, pull boxes, transformers, motor control centers, VFDs, etc.

12. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

13. Install pull wires in empty raceways. Use #14 AWG zinc-coated steel or monofilament plastic line having not less than 200-pound tensile strength. Leave not less than 12 inches of slack at each end.

14. Telecommunications and Signal Systems Raceways: Refer to Section 27 05 28 Pathways for Communications.

15. Install raceway-sealing fittings in accordance with the manufacturer’s written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL Listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway-sealing fittings at the following points and elsewhere as indicated:
   a. Where conduits enter or leave hazardous locations.
   b. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
   c. Where required by the NEC.

16. Flexible Connections: Use short length (maximum of 6 feet) of flexible conduit for recessed and semi-recessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid tight flexible conduit in wet locations. Install separate ground conductor in all flexible connections.

17. Conduit Seals: Conduit passing through concrete walls shall be sealed.

18. Where conduits are to be installed through structural framing members, the contractor shall provide sleeves. Cut all openings in concrete with rotary type drill, or other method as approved by the University Project Manager. Holes cut with pneumatic hammer will not be accepted. For areas where sleeves have not been provided, the Engineer’s written approval must be obtained prior to cutting, notching or drilling of structural framing members.

19. Ream the ends of all cut and/or threaded conduit. Ends shall be cut square.

20. Use of running threads for rigid metallic conduit are not permitted. When threaded couplings cannot be used, provide 3-piece union or solid coupling.

21. Conduits shall not cross pipe shafts or ventilation duct openings “access panel”.

22. Conduit shall not obstruct full and direct access to equipment requiring maintenance. This includes but is not limited to valves, actuators and terminal box controllers.

23. Install an insulated ground conductor in all conduits.

24. Where individual conduits penetrate fire-rated walls and floors, provide pipe sleeve one size larger than conduit; pack void around conduit with fire rated insulation and seal opening around conduit with UL Listed foam silicone elastomer compound. Conduits on trapeze type support system shall require fire taping only.

25. Where conduit sleeves penetrate fire rated floors or walls for installation of system cables, AC or MC cables, or modular wiring cables, pack void around cables or empty sleeve with fire rated insulation and fill ends with fire-resistive compound. Seal opening around sleeve with UL Listed foam silicone elastomer compound.
26. Provide separate raceway systems for each of the following:
   a. Lighting
   b. Power Distribution
   c. Emergency (Essential)
      1) Lighting
      2) Power distribution
   d. Low voltage systems, including telephone and communications, EQ alarm, security, fire alarm.
   e. Audio/Visual

27. Provide for waterproofing of all raceways, fittings, etc., which penetrate the roof to preserve the weatherproof integrity of the building. Installation of materials shall conform to the following:
   a. General:
      1) Install all raceways concealed except at surface cabinets, for motor and equipment connections and in mechanical equipment rooms. Install a minimum of 6 inch from flues, steam pipes or other heated pockets for water-flashing and counter-flashing or pitch pockets for waterproofing of all raceways, outlets, fittings, etc., which penetrate roof. Route exposed raceways parallel or perpendicular to building lines with right angle turns and symmetrical bends. Concealed raceways shall be run in a direct line, and where possible, with long sweep bends and offsets.
      2) Provide raceway expansion joints with necessary bonding conductor at building expansion joints and where required to compensate for raceway or building thermal expansion and contraction. Terminate raceways 1-1/4 inch and larger with insulated bushing or rain tight connections with insulated throats.

28. Special areas methods for raceway installation (with appropriate seal-offs, explosion-proof fittings, etc.), in all special occupancy areas, as defined and classified in Article 500 of the National Electric Code (NEC), shall be in accordance with that Article.

29. If type MC or AC cable is used for branch circuits, the home run conduit will be EMT and must run from the panel to within 10 feet horizontally of the first device served.

30. All underground raceways, not under the building footprint, shall be installed so it slopes away from the building.

D. Raceway Installation:
   1. Surface raceways, where indicated on drawings, shall be metal and of a size approved for number and size of wires to be installed, shall be installed in a neat, workmanlike manner, with runs parallel or perpendicular to walls and partitions. Raceways, elbows, fittings, outlets and devices shall be of same manufacturer, and designed for use together.
   2. Wire ways, where indicated, complete with elbows, tees, connectors, adaptors, etc., with all parts factory-fabricated and of same manufacture.

3.2 INSTALLATION, GENERAL

A. Boxes:
   1. Every J-box shall be secured, independent of conduit entries into the box. Boxes shall be secured to the building structure. Ceiling wire shall not be used to support (secure) J-boxes.
   2. Box fill shall be governed by code requirements. Only the allowable amount of conduit entries shall be allowed into the box.
   3. Box covers shall be marked so as to indicate the voltage, panel number, and circuit number of the enclosed conductors.
   4. Each J-box shall have only one voltage installed.
   5. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
   6. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.
   7. Remove sharp edges where they may come in contact with wiring or personnel.
   8. All conduits connected to a flush panel shall be concealed.

B. Outlet Boxes:
1. Exact location of outlets and equipment shall be governed by structural conditions and obstructions or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment. Verify final location of all outlets, panels, equipment, etc. with the University Project Manager.

2. Switch Outlet and Panel board height dimensions to meet ADA requirements.

3. Above counters, benches, special equipment, baseboards, fin tube radiators, etc., or at wainscoting, outlets shall be mounted minimum 6 inches above to prevent interferences to service equipment, or as noted on drawings.

4. Fire rated poke-through shall be installed in areas to miss beams and ductwork in ceiling below. Floors shall be X-rayed before core drilling.

5. Outlets at windows and doors: Locate close to window trim in an accessible location. For outlets indicated above doors center outlets above the door opening except as otherwise indicated.

6. Column and pilaster locations: Locate outlet boxes for switches and receptacles on columns or pilasters so the centers of the columns are clear for future installation of partitions. Locate in an accessible location.

7. Locations in special finish materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

8. Mounting: Mount outlet boxes for switches and receptacles with the long axis vertical or as indicated. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the strike side, close to door trim. Provide far side box supports for electrical boxes installed on metal studs.

9. Ceiling outlets: For fixtures, where wiring is concealed, use outlet boxes 4-inches square by 1-1/2 inches deep, minimum.

10. Protect outlet boxes to prevent entrance of plaster, and/or debris. Thoroughly clean foreign material from boxes before conductors are installed.

11. Concrete boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6-inch depth.

12. Existing outlet boxes: Where extension rings are required to be installed, drill new mounting holes on the existing boxes where existing holes are not aligned.

13. Back to back outlet boxes are not permitted. Separate boxes a minimum of 6 inches in standard walls and 24 inches in acoustical walls.

C. Installation of Pull and J-Boxes:

1. Box selection: For boxes in main feeder conduit runs, use minimum 8-inches square by 4-inches deep or as needed per NEC. Do not exceed 6 entering and 6 leaving raceways in a single box.

2. Cable supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inches inside boxes.

3. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.

4. Every J-box shall be secured, independent of conduit entries into the box. Boxes shall be secured to the building structure. Provide rigid supports for all J-boxes, ceiling wire supports are not acceptable.

5. Box fill shall be governed by code requirements. Only the allowable amount of conduit entries shall be allowed into the box.

6. Box covers shall be marked so as to indicate the voltage, panel numbers, and circuit number of the enclosed conductors. Use pre-printed labels, marking cover with permanent marker is not acceptable.

D. Grounding:

1. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box or enclosure.

E. Outlets:
1. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4 inch octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8-inch no-bolt fixture studs. Where fixtures are mounted on or in an accessible type ceiling, provide a J-box and extend flexible conduit, maximum 6’ to each fixture. Outlet boxes in finished ceilings or walls shall be fitted with appropriate covers, set to come flush with the finished surface. Where more than one switch or device is located at one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide tile box or a 4-inch square box with tile ring where "drywall" type materials are applied.

F. Pull and J-Boxes and Cabinets:
1. Construct J-boxes or pull boxes not over 150 cubic inches in size as standard outlet boxes, and those over 150 cubic inches the same as "Cabinets," with hinged covers of same gauge metal. Removable covers must be accessible at all times.
2. Provide a standard access panel having a hinged metal door neatly fitted into a flush metal trim, where a J-box or equipment is located above non-accessible ceilings or behind finished walls. Coordinate location and type with the University Project Manager. Access panels shall be minimum 24”x24” or 6” larger than pull box.
3. All cabinets shall be set rigidly in place with fronts straight and plumb, center panel board interiors in door openings.

END OF SECTION 26 05 33
SECTION 26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Underground Electrical Primary:
   1. Service (primary) – Main Campus primary distribution is owned by the university. Assume all systems are ungrounded in cable standards.
   2. Unless otherwise stated during the pre-design conference, the university will provide and underground junction point or switch point within the contract limits (or close by) for termination of primary building feeder. Contractor will provide and install raceway and conductors between said junction point and the building transformer.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Underground Electrical Primary:
   1. Duct Bank (primary): Concrete encase underground 13.8 kV raceway. Raceway may be P.V.C. Type 1 or equivalent. Concrete envelope shall be red color and shall be a minimum of 4 inch all around cover. (Example: 4-inch raceway would require 12 inch cross section of concrete).
   2. Primary Cable: 15 kV class cable to be single copper conductor, 220 mil insulated for ungrounded type service, shielded, 90 degree C rated, with copper conductor cable.
   3. Ground: No. 4 AWG with THWN 600 volt insulation copper wire in raceway with primary service to building. Tie said ground wire to common system ground of building.
   4. All conduits entering or exiting buildings shall be hull wall rigid metal conduit to minimize future shearing of conduits. After leaving building excavation, the transaction to other types of conduits can be made.
   5. Warning tape shall be buried 6 inches deep on top of buried electrical and control wiring. The tape shall be inert plastic film highly resistant to alkalis, acids, or other destructive chemical components likely to be encountered in soils. The tape shall be 3 inches wide, colored Red and imprinted with “CAUTION: BURIED ELECTRIC LINE BELOW”.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Underground Electrical Primary:
   1. Install duct in accordance with manufacturer’s recommendations. Install duct at depth and locations as indicated on drawings. Install duct with a minimum slope of 4 inches per 100 feet. Slope duct away from building. Provide suitable fittings to accommodate expansion and deflection.
   2. Band ducts together before placing concrete. Securely anchor to prevent movement during placing of concrete. Stagger duct joints vertically in concrete encasement. Provide two (2) - #4 steel reinforcing bars in top of bank under paved areas.
   3. Swab duct. Use suitable caps to protect installed duct.
   4. Install cable and accessories in accordance with manufacturer’s instructions.
   5. Avoid abrasion and other damage to cable during installation. Use suitable lubricants and pulling equipment. Do not exceed cable pulling tensions and bending radius.
   6. Ground cable shield at each termination and splice.
   7. Install cables in manholes along wall providing longest route. Arrange cable in manholes to avoid interference with duct entrances. Fireproof cables in manholes using fireproofing tape in half-lapped wrapping. Extend fireproofing on inch into duct.
8. Provide PVC coated rigid conduit for all 90 degree elbows.

END OF SECTION 26 05 43
SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. All electrical equipment and systems shall be properly labeled in accordance with this section. It includes requirements for electrical identification components including but not limited to the following:
   1. Identification labeling for raceways, cables, and conductors.
   2. Equipment labels and signs.

1.2 SUBMITTALS

   1. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

   A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
      1. Ideal Industries, Inc.
      2. LEM Products, Inc.
      3. Markal Corp.
      4. Panduit Corp.
      5. W.H. Brady, Co.

2.2 MATERIALS, GENERAL

   A. Nameplates: Engraved plastic laminate, black letters on white background for normal systems and white letters on red background for emergency systems.

   B. Electronic Labels: 9mm self-adhesive tape, black letters on clear for normal systems and red letters on clear for emergency systems. Embossed DymoType labels are not accepted.

   C. Wires and Cable Markers: Cloth markers, split sleeve and tubing type.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

   A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

   B. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. Degrease and clean surfaces to receive nameplates and labels.

   C. Conduit Identification: Use adhesive marking labels at 40 foot intervals to identify all conduits run exposed or located above accessible ceilings. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible. Use the following colors:
      1. 600 Volt and Below: Black letters on orange background indicating feeder identification and
      2. Other Systems: Provide color banding as specified below.
D. Identify System Raceways with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be pre-tensioned, snap-around colored plastic sleeves, colored adhesive marking tape, or a combination of the two. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 40-foot maximum intervals in straight runs. Provide Brady B-946 vinyl or equivalent. Colored duct tape is not acceptable. Apply the following colors:
1. Security System: Blue and Yellow with Gray Cable.
2. Telecommunications System: Green and Yellow with Blue and White Cables.
6. Lighting Control Cabling shall be Green.

E. Identify Junction, Pull, and Connection Boxes: Identification of systems and circuits shall be pressure-sensitive, self-adhesive label indicating system voltage and identity of contained circuits on outside of box cover. Color code shall be same as conduits for pressure sensitive labels. Use pressure-sensitive plastic labels at exposed locations and indelible marker (black or red) at concealed boxes. All fire alarm boxes shall have covers painted red.

F. Power Circuit Identification: Tag or label conductors as follows:
1. Multiple Circuits: Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure label each conductor or cable including neutrals. Provide legend indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by means of coded color of conductor insulation. For control and communications/signal wiring, use color coding or wire/cable marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.
2. Match identification markings with designations used in panel boards shop drawings, Contract Documents, and similar previously established identification schemes for the facility’s electrical installations.

G. Install equipment/system circuit/device identification as follows:
1. Apply equipment identification labels of engraved plastic-laminate on each major unit of electrical equipment in building, including central or master unit of each electrical system. This includes communication/signal/alarm systems, unless the unit is specified with its own self-explanatory identification. Text shall match terminology and numbering of the Contract Documents and shop drawings. Identification must include equipment name, voltage, phase, amperage, and fed from.. Apply labels for each unit of the following categories of electrical equipment.
   a. Switchboards, switchgear, panelboards and enclosures, 1/2” high lettering.
   b. Access doors and panels for concealed electrical items, 1/4” letters
   c. Transformers 1/2” high letters.

H. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panel boards and alarm/signal components, where labeling is specified elsewhere.

I. For panel boards, provide framed, typed circuit schedules (label all spares and spaces in pencil) with explicit description and identification of items controlled by each individual breaker.

J. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
K. Provide tape labels for identification of individual receptacle and switch wall plates. Locate tape on front of plate and identify branch circuit serving the receptacle or switch.

END OF SECTION 26 05 53
SECTION 26 09 43 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Provide distributed network lighting control system. Define the lighting control zones to individual rooms, areas or individual fixtures as coordinated with the university Facilities Group.

B. Interface lighting control zones with the Building Automation System (BAS) control zones. Provide all hardware, cabling and software interface as needed for required Bacnet communications interface.

C. Provide minimum 25% spare capacity including equipment ratings, housing capacities, spare relays, terminals and controls.

D. Provide a graphic user interface with a graphic display for programming lighting control zones.

1.2 PERFORMANCE REQUIREMENTS

A. Provide lighting control software capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses and assigning switch inputs and relay outputs modes.

B. Provide automatic time controls with automatic adjustment of dawn to dusk switching. System shall automatically adjust for leap year and daylight savings time.

C. Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval.

D. System shall include daylight harvesting control capabilities.

E. Provide system with energy usage reporting which can be downloaded to the BAS.

1.3 SUBMITTALS

A. Provide shop drawings with complete layout of all lighting control equipment including but not limited to programmable controllers, network cable, relays, switches, occupancy sensors and photocell sensors.

B. Provide one-line diagrams showing the relative placement of all equipment and interconnections to equipment supplied by other manufacturers.

C. Provide complete wiring details showing connections to relays, switches, occupancy sensors, photocell sensors, etc.

D. Clearly identify lighting zones which are coordinated and interface with the BAS control zones. Coordinate with Division 23.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers: subject to compliance with requirements, provide programmable lighting control equipment of one of the following (for each type and rating of equipment).

2.2 SYSTEM REQUIREMENTS

A. Provide windows graphic user interface for programming and status of lighting control system.

B. Reports: Energy performance reports shall be printable in a printer friendly format and downloadable for use in spreadsheet applications, etc.

C. Interoperability: Control module shall be configured to connect to a BACnet-compliant network, resulting in extending control to any network-compliant devices such as occupancy switches.

D. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the System, the control unit will reduce its output to a programmable maximum electrical demand load. The System shall not shed more load than required and load shedding priority shall be centrally configurable by light fixture. The individual user shall retain the ability to override System light levels.

E. Emergency Mode: There shall be a mode, when activated through the System, that will immediately adjust lights to full light output and retain that level until the mode is deactivated. This setting shall override all other inputs. The System shall interface with the building emergency monitoring system at a convenient point and not require multiple connections.

F. Addressing: I/O Modules shall be centrally addressable, on a per fixture basis, through the software. To simplify installation and maintenance, the System shall not require manual recording of addresses for commissioning or reconfiguration.

G. LAN Operations: System shall operate independently of building’s existing network infrastructure and shall not rely on tenant supplied PCs for operation. Network infrastructure shall only be utilized for software. Manufacturer must provide software to facilitate communications. Manufacturer shall provide connection from the PC running energy management and lighting control software to the System communication bus.

H. Firewall Security: System firewall technology shall maintain network security.

I. Re-configurability: The assignment of individual fixtures to zones shall be centrally configurable by software such that physical rewiring will not be necessary when workspace reconfiguration is performed. Removal of covers, faceplates, ceiling tiles, etc. shall not be required.

2.3 I/O MODULE

A. General:
   1. Addressing: All I/O modules shall be individually addressable via software.
   2. Memory: Retains all system settings in non-volatile memory.
2.4 WALL CONTROLLERS

A. General
   1. Addressing: All wall modules shall be individually addressable via software.
   2. Memory: Retains all system settings in non-volatile memory.
   3. Ratings: Shall be low voltage input.

2.5 PHOTO SENSOR

A. General
   1. Addressing: All photo sensors modules shall be individually addressable via software.
   2. Memory: Retains all system settings in non-volatile memory.
   3. A sensor that measures ambient light in a finite area shall be available.
   4. Mounting: The sensor shall be flush mounted on or recessed inside ceiling tile.

2.6 OCCUPANCY SENSORS

A. General:
   1. Addressing: All I/O modules shall be individually addressable via software.
   2. Memory: Retains all system settings in non-volatile memory.
   4. Sensor timeouts shall be configurable by System software. Above the minimum sensor timeout setting.
   5. Mounting: Sensors for mounting on ceilings and walls, including corners, must be available.

2.7 LIGHTING CONTROL PANELS

A. General
   1. Addressing: All relays shall be individually addressable via software.
   2. Memory: Retains all system settings in non-volatile memory.
   3. Wiring: Relay control panels shall be interconnected with any other devices on the same wiring loop.

PART 3 - EXECUTION

3.1 ENCLOSED OFFICES

A. Provide occupancy sensor control in all offices with manual override controls. Configure office with manual on and auto off controls.

B. Provide daylight harvesting controls for all perimeter offices by switching off fixture(s) when adequate daylight is detected by photocell.

C. Interface occupancy sensor with BAS controls.

3.2 OPEN OFFICE

A. Provide occupancy sensor control in all open office areas. Configure open office with auto on/off.

B. Provide daylight harvesting controls for all fixtures adjacent to exterior windows or skylights. Switch off fixtures when adequate daylight is detected by photocell.

C. Interface occupancy sensor with BAS controls.
3.3 CONFERENCE ROOMS

A. Provide multi zone controls for all conference rooms. Coordinate zones with audio/visual systems to allow for video and projection presentations, video conferencing, etc. Light fixtures closest to the projections screen or monitor shall be on a separate lighting zone form the rest of the room. Coordinate with Educational Services.

B. Provide occupancy sensor controls configured with manual on and auto off controls.

C. Interface occupancy sensor with BAS controls.

D. Provide low voltage controls to all motorized shades and projection screens.

3.4 LOBBIES AND CORRIDORS

A. Provide time clock controls configured for automatic on/off.

B. Coordinate on/off times with the university project manager.

C. Egress lighting may be controlled under certain conditions. Coordinate with the University Project Manager.

3.5 SPECIALTY AREAS

A. Coordinate lighting control requirements with the university project manager for all specialty areas such as but not limited to laboratories, conference centers, animal facilities and clinical facilities.

3.6 EXTERIOR

A. Provide control of all parking poles, pedestrian poles, building fixtures and emergency ring down light fixtures.

B. Provide photocell on with time clock off controls. Coordinate with the university for time function.

3.7 PARKING GARAGE

A. Provide photocell control of perimeter fixtures for daylight harvesting controls. Switch fixtures off when adequate daylight is present.

B. Control light fixtures at drive entry locations such that higher light levels are provided during daytime hours and lower light levels at night.

3.8 ANIMAL CARE FACILITIES

A. Provide a separate lighting control system from the building control with graphic screens. Provide full manual override capabilities from the lighting control computer.

B. Provide automatic controls with a 12-hour On/Off cycle at the half light level of 30 foot-candle in each holding room. Review with the University Project Manager.

D. Provide red filter over a single lamp, verify spectrum with the university. Provide manual “On” switch inside each holding room with a 15-minute delay.

E. Provide all holding rooms with positive verification back to lighting control computer.

3.9 LECTURE HALL/AUDITORIUM

A. Provide dedicated dimming control system with multi-zone capabilities.

B. Coordinate zones with audio/video system to allow for video and projection presentations, video conferencing, etc. Provide light fixtures closest to the projection screen or monitor on a separate lighting zone from the rest of the room.

C. Provide low voltage control to all motorized shades and project screens.

D. Provide interface with A/V control panel.

END OF SECTION 26 09 43
SECTION 26 20 00 - LOW VOLTAGE ELECTRICAL DISTRIBUTION

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Motors, Starters and Protection: Electrical contractor will supply and install all motor controllers and disconnect switches.

B. Panelboards:
   1. Provide a minimum of four (4) – 3/4” spare conduits out of panels. Run empty conduit to accessible spaces and label conduits as spare.
   2. All lighting and power panels will be specified to provide minimum of 30% spare capacity and spare breaker space.
   3. A/E will provide panel indexes on contract drawings. Final indexes to be provided and installed by the Contractor will correspond to final university room number schedule.
   4. The switching of lights from lighting panels is acceptable only if specifically approved by the university CBO, through the University Project Manager; and if approved, a separate panel will be provided for circuits, which are to be controlled. No circuits other than lighting will originate in the panel thus provided. In the rare instance of lights being switched by breaker, provide switch-rated breakers.

C. Grounding and Testing: Transformer neutrals of separately derived systems secondaries will be grounded by way of a grounding conductor between the secondary neutral and grounding buss at the main service entrance equipment. Size determined in accordance with NEC.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Cartridge Fuses:
      a. Bussmann Div., Cooper Industries, Inc.
      b. Littelfuse Inc.
      c. Or equal
   2. Fusible Switches:
      a. Square D Co.
      b. Allen-Bradley Co.
      c. General Electric Co.
   3. Eaton-Cutler Hammer Molded-Case Circuit Breakers:
      a. Square D Co.
      b. General Electric Co.
      c. Siemens Energy & Automation, Inc.
      d. Eaton-Cutler Hammer ABB Power Distribution, Inc.
   4. Combination Circuit Breaker and Ground Fault Circuit Interrupters:
      a. Square D Co.
      b. General Electric Co.
      c. Siemens Energy & Automation, Inc.
   5. Eaton-Cutler Hammer Safety Switches:
      a. Siemens – Energy Automation Or equal
   6. Motor Starters:
      a. Allen-Bradley Co.
   7. Panelboards:
b. Square D  
c. Eaton-Cutler Hammer  
d. Panelboards shall match existing throughout facility in remodel situations.

8. Motor Control Centers:
   a. Allen - Bradley  
   b. ITE  
   c. GE  
   d. Square D  
   e. Westinghouse/Cutler Hammer

2.2 MATERIALS, GENERAL

A. Motor Starters:
   1. Shall be combination circuit breaker (magnetic only) full voltage magnetic type with 3-leg  
      overload protection in NEMA I enclosure. Provide 2 interlock contacts of interchangeable open-  
      close type. Provide hand-off automatic selector, motor running transformer type red LED pilot  
      light and reset button in cover. Control circuits shall be provided with individual 120-volt control  
      transformers. Starters shall be furnished under electrical contract. Size starts as required by NEC.  
   2. Starters for fractional horsepower (1/2 HP or less) 120-volt motors shall be manual type, unless  
      shown otherwise, equipped with built-in overload protection. All magnetic starters shall be of one  
      manufacturer. For all thermal overload switches provide General Electric type CR101 or equal of  
      other acceptable manufacturer.  
   3. All motors larger than 1/2 HP shall be 3 phase.  
   4. Motors above 25 HP will require step starting or VFDs to limit starting current.  
   5. All motors to be provided with external overload running protection. This is in addition to any  
      ‘built-in’ protection inherent in the motor.  
   6. All motors of 1-1/2 HP and larger shall be of a high or premium efficient type and have an  
      efficiency of not less than those values as stated in the IEEE test procedures, 112A Method B.  

B. Panelboards:
   1. Panelboards shall be bolt on, circuit breaker type. Panelboard bus shall be copper and shall be size  
      to meet the continuous and short circuit rating as shown on the drawings.  
   2. All panel covers will be factory painted with low gloss enamel (not flat wall paint) suitable for  
      metal. No field painting will be permitted. Toggle type covers not acceptable.  
   3. Panelboards shall be of door-in-door construction.  
   4. Panelboards shall be fully rated. The use of Series rated panelboards is prohibited.  
   5. Non linear land panelboards shall be provided in areas with heavy computer boards or laboratory  
      equipment leads. These panelboards shall be provided with 200% neutrals.

C. Power Factor Correction: All motors 20 HP and larger will be power factor corrected to a minimum of  
   95% at design load. HVAC systems may be corrected at the motor control center.

D. Over current Protective Device:
   1. General: Provide OCPDs in indicated types, as integral components of panelboards, switchboards,  
      motor control centers, and other related equipment; and also as individually enclosed and mounted  
      single units.  
   2. Where OCPDs are to be installed in existing panelboards, switchboards, and motor control  
      centers, they shall be of the same manufacture and type as those existing in the equipment.

E. Cartridge Fuses:
   1. General: Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types,  
      classes, and current ratings that have voltage consistent with the circuits on which used.  
   2. All fuses used for main, feeder, or branch-circuit protection shall be UL listed, current limiting  
      fuses with 200,000 ampere interrupting rating and shall be so labeled. Fuses used for  
      supplementary protection (other than branch circuit protection) shall be as specified above or shall  
      be UL approved or component recognized for such purposes. The same manufacturer shall furnish
all fuses provided. Should equipment provided require a different UL class or size of fuse, the
engineer shall be furnished sufficient data to ascertain that system function will not be adversely
affected.
3. Fuses over 600 amperes shall be UL Class "L" fuses; and shall have minimum time-delay of 10
seconds at 500% rating.
4. To simplify fuse replacement, reduce spare fuse inventory and insure adequate thermal protection,
all fuses 600 amperes and below shall be true dual-element time-delay fuses with separate spring-
loaded thermal overload elements in all ampere ratings. All ampere ratings shall be designed to
open at 400 degree F or less when subjected to a non-load oven test.
5. To eliminate induction heating, all fuse ferrules and end caps shall be non-ferrous and shall be
bronze or other alloy not subject to stress cracking.
7. Class RK1 and RK5 Dual Element Time-delay Fuses: UL 198E, “Class R Fuses.”

F. Fusible Switches:
1. General: UL 98 “Enclosed and Dead Front Switches” and NEMA KS-1 “Enclosed Switches,”
quick-make, quick-break, heavy-duty units.
2. Rating: Load-breaking capacity in excess of the normal horsepower rating for the switch.
3. Withstand Capability: In excess of the let-through current permitted by its fuse when subject to
faults up to 100,000 RMS symmetrical amperes.
4. Operation: By means of external handle.
5. Interlock: Prevents access to switch interior except when in “off” position.
6. Fuse Clips: Rejection type.
7. Padlocking Provisions: For 2 padlocks whether open or closed.
8. Enclosure for Switchboard or Panel board Mounting: Suitable for panel mounting where indicated.
10. Enclosure for Independent Mounting: NEMA Type 1 enclosure except as otherwise indicated or
required to suit environment where located.
11. Contacts shall be NEMA rated 75 degree C.
12. Provide fuses for safety switches and other equipment of classes, types, and rating needed to fulfill
electrical requirements for services indicated.
13. Provide auxiliary contacts for disconnects supplied from variable frequency drives.

G. Safety Switches:
1. Heavy-duty type, horsepower rated for motors. Quick-make, Quick-break, load interrupter
enclosed knife switch with externally operable handle. Handle shall be lockable in the “off”
position.
2. Standard enclosure NEMA 1 indoors and NEMA 3R weather-tight outdoors.

H. Molded-case Circuit Breakers:
1. General: UL 489, “Molded Case Circuit Breakers and Circuit Breaker Enclosures,” and NEMA
AB 1, “Molded Case Circuit Breakers.”
3. Characteristics: Indicated frame size, trip rating, number of poles, and a short-circuit interrupting
capacity rating of 10,000 amperes symmetrical for 120 and 208 volt devices and 14,000 amperes
symmetrical for 277 and 480 volt devices, unless a greater rating is indicated or required to match
existing devices or equipment.
4. Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and
instantaneous over current trip protection for each pole.
5. Solid State Molded Case Circuit Breakers: Provide with electronic sensing, timing and tripping
circuits for adjustable current settings; ground fault trip, instantaneous trip and adjustable short
time and long time. The instantaneous shall be capable of being turned on and off on the main
service breaker only.
6. Enclosure for Switchboard or Panel board Mounting: Suitable for panel mounting in switchboard
or panel boards where indicated.
7. Enclosure for Switchboard or Motor Control Center Mounting: Provide individual mounting where indicated.
8. Enclosure for Independent Mounting: NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

I. Combination Circuit Breakers and Ground Fault Circuit Interrupters: UL 943, “Ground Fault Circuit Interrupters,” arranged for sensing and tripping for ground fault current in addition to over current and short-circuit current. Provide features as follows:
   1. Match features and module size of panel board breakers and provide clear identification of ground fault trip function.
   2. Trip Setting for Ground Fault: Recalculate / reset as required by additional loads in excess of 100A @ 480v 3-phase.

J. Distribution Switchboard:
   1. NEMA PB 2 with electrical ratings and configurations as indicated. Main section shall be individually mounted. Distribution devices shall be group mounted. Provide for future provisions.
   2. Bus material shall be copper and shall be fully insulated. Bus connections shall be bolted and shall be accessible from the back. Ground bus shall run the entire length of the switchboard.
   3. Line and Load Terminations: Accessible from the front. Suitable for the conductor size and type shown.
   5. Align sections in front. Switchboard height shall be 90 inches. Finish shall be manufacturer's standard light gray. Mimic bus shall be provided.

K. Motor Control Center
   1. NEMA ICS 2, Class II Type A, B or C. Voltage and current ratings shall be as shown on the drawings. Enclosure shall be NEMA ICS 6 Type 1 or 2.
   2. Main over current protection shall be molded case circuit breaker sized as shown on the drawings.
   3. Vertical and horizontal bus shall be copper and rated as shown on drawings.

L. Secondary Substation: Secondary substations are prohibited without prior approval from the university facilities.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Maintenance Stock Fuses: Refer to Section 01 78 46 – Extra Stock Materials.

B. Independently Mounted OCPDs: Locate as indicated and install in accordance with manufacturer’s written installation instructions.

C. OCPDs in distribution and branch circuit equipment shall be factory installed.

D. Connections: Check connectors, terminals, bus joints, and mountings for tightness. Tighten field-connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

E. Grounding: Provide equipment-grounding connections for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

F. Panel boards:
1. Except as otherwise noted, locate panel boards as follows: Dimensions given are from finished floor.
   a. 6'-6" to top of trim.
2. Contractors who are modifying or installing new electrical panels must redo the panel directory making the directory current. In the case of a new panel, the panel directory must coincide with actual (correct) building room numbers. Panel schedules need to be updated when extra circuits are added or when the entire panel is upgraded, such as with remodel jobs. Final directory shall be typed, hand written directories are not acceptable.
3. Only one wire per breaker will be allowed.
4. Wire shall be neatly formed to contour with the panel box. Remove all excess wire lengths.
5. Every panel shall have a grounding bar installed in its interior. Attached to the grounding bar shall be a grounding conductor taken to earth ground and/or a domestic water copper or metal pipe when appropriate as required by NEC.
6. An energized panel shall not be left exposed or unlocked to the general public, such as in a hallway, office, or other pedestrian walkway. Panel covers shall be reinstalled at the end of the workday.
7. Attach panel boards to concrete walls or floors with a concrete type anchor approved for the purpose that requires drilling of the concrete and manually driving in the anchor by force. Do not use powder-actuated or plastic anchors to secure panel boards. Do not use horizontally approved anchors for vertical applications.
8. Panel identification is imperative. The panel shall be identified on the outside of the panel cover per Section 26 05 53.
9. Panel cover hardware shall be replaced if broken or not operating properly.
10. Breakers shall be labeled odd numbers on left side; even numbers on right side.
11. Match existing building equipment wherever possible and/or coordinate with the University Project Manager.
12. Provide externally mounted TVSS units for all Information Technology panels.

G. Switchboards:
1. Install switchboard on 4-inch housekeeping pad. Install switchboards in accordance with manufacturer's recommendations. Tighten bus connections after placing switchboard.
2. Coordinate size of switchboard with door openings and access corridors to assure that switchboards can be moved after structure is complete.

H. Motor Control Centers (MCC): Install MCC on 3-inch housekeeping pad. Install MCC in accordance with manufacturer's recommendations.

I. Electrical panels, switchgear, and any kind of electrical distribution boards shall not be worked hot.

J. All mechanical ductwork and piping not directly serving the electrical room shall be prohibited in electrical room. All plumbing piping, and storm drains are prohibited to be routed through electrical rooms.

K. Provide a framed record drawing of the complete and final electrical distribution one-line. Mount in the main electrical room.

L. Secondary Unit Substation:
1. Install 3-inch housekeeping pad for unit substation.
2. Install in accordance with drawings and manufacturer’s instructions.

END OF SECTION 26 20 00
SECTION 26 21 00 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Primary Transformers:
   1. Electrical transformers will be included as part of the project design and will be located during the design phase.
   2. Transformers used to step down from the university 13.2KV primary voltage to building utilizable voltage shall be non-PCB liquid-cooled and insulated and installed in accordance with Article #450 of the National Electric Code (NEC).
   3. Where building transformer is to be furnished under the building contract, the size is to be determined by the Engineer. All sizing is to be approved through the University Project Manager.
   4. Primary Voltage 13.2 KV 3-phase delta with wye secondary. Specify with (2) 2 1/2% above and (2) 2 1/2% below normal taps with externally-operated no load trip charger.
   5. Provide exterior pad mounted transformers adjacent to building being served. Coordinate location with the University Project Manager during Design Development Phase.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subjects to compliance with requirements, provide products by the following:
   1. Primary Transformers: Cooper, ABB, GE, Square D.

2.2 MATERIALS, GENERAL

A. Primary Pad Mounted Transformers:
   1. Liquid-filled Transformers: ANSI C57.12.22; three phase, pad mounted, self-cooled, copper wound transformer unit, 98KV BIL.
   2. Transformer capacity, primary voltage, secondary voltage, and impedance shall be as specified on the drawings.
   3. Provide standard primary taps, with externally operated tap changer.
   4. Cooling and Temperature Rise; ANSI C57.12.22; Class OA. 65 degree C, self-cooled.
   5. Liquid: Electrical Grade Mineral Oil.
   6. Accessories: ANSI C57.12.22 standard accessories including magnetic liquid level pressure gauge and dial type thermometer.
   7. Primary Terminations: Bushing wells to ANSI/IEEE 386; provide radial or loop feed as specified on drawings. Include bushings for insulated load break connectors.
   8. Primary Switching and Protection: As indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install in accordance with drawings and manufacturer’s recommendations.
B. Install safety labels to NEMA 260.
C. Transformer clearances shall comply with Xcel Energy requirements.
D. Provide loop feed to all transformers.
E. Keep conduits/conductors clear from oil test port. Provide exterior mounted test port if clearance cannot be maintained.

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Test dielectric liquid to ASTM D877, using 25,000 volts minimum breakdown voltage, after installation and before energizing from system.

B. Test transformer to ANSI/IEEE C57.12.90.

C. Cable Testing: Perform DC high potential test of each conductor in accordance with NEMA WC 3. Connect untested conductors in circuit to ground during test. Apply test voltage in at least eight equal increments to maximum test voltage. Record leakage current at each increment. Allowing for charging current decay. Hold maximum test voltage for ten minutes.

END OF SECTION 26 21 00
SECTION 26 22 00 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESIGN PERFORMANCE

A. Size transformers based on calculated load plus 20% spare capacity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptance Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Cutler Hammer
   2. Siemens
   3. General Electric
   4. Square D

2.2 MATERIALS, GENERAL

A. Description: Transformers shall be NEMA ST 20, factory assembled, air cooled, altitude corrected, copper wound dry-type distribution transformers of sizes, characteristics and ratings indicated, designed to supply a 100% nonlinear load. Winding taps per NEMA ST 20.

B. Transformers shall have 220 degree C, Class H insulation. All transformers shall be rated for 115 degree C maximum temperature rise above 40 degrees C ambient.

C. Provide ventilated drip-proof, conventional type metal housings for indoor service. Provide all necessary supports, rods, and hangars to properly and securely support transformer in location indicated.

D. All windings shall be of high quality copper.

E. Winding Taps:
   1. Transformers Less than 15 kVA: Two 5% below rated voltage, full capacity taps on primary winding.
   3. Transformers shall have 480 volt, 3 phase, 3 wire primary and 120/208 volt, 3 phase, 4 wire, 60 hertz, wye connected secondary unless otherwise noted.

F. Sound Levels: Maximum sound levels are as follows: NEMA ST 20.

G. Basic Impulse Level: 10 kV for transformers.

H. Ground core and coil assembly to enclosure by means of a visible flexible copper-grounding strap.

I. Mounting: Mount on 4” housekeeping pad.

J. Coil Conductors: Continuous windings with terminations brazed or welded.

K. Enclosure: NEMA ST 20; Type 1, ventilated. Provide lifting eyes or brackets.

L. Transformers shall be supplied with factory installed internal vibration absorbing isolators to isolate core and coil from enclosures.
M. Nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install transformer in accordance with manufacturer's instructions.

B. Set transformer on house keeping pad plumb and level. Suspended transformers are prohibited without prior approval from the University Project Manager.

C. Use flexible conduit, under the provisions of Section 26 05 33 2ft (0.6 M) minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure, bottom entry is not acceptable.

D. Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

E. Bond transformer according to Article 250 of the NEC.

END OF SECTION 26 22 00
PART 1 - GENERAL

1.1 DESIGN PERFORMANCE

A. All electrical loads connected to the campus electrical distribution system will be required to be metered utilizing a power and energy meter. The campus is a single electric metering premise for the local utility provider and is billed as a single user. The billed amount is required to be allocated across the campus by metering at all load points.

B. Provide electric metering at all service entry mains for each distribution panel at each building. Minimum requirements will be a multi-function revenue grade energy and power quality meter with datalogging and waveform capture and digital display. Buildings with highly sensitive research equipment will utilize a high performance energy and power quality meter with datalogging and waveform capture.

C. Provide submetering at each building load distribution center outgoing feeder for load monitoring. Minimum requirements will be a revenue grade energy and power meter with digital display.

D. Provide submetering for all temporary construction service loads. Minimum requirements will be a revenue grade energy and power meter with digital display.

E. Provide integration to Building Automation System (BAS) for each meter by way of campus ethernet. Acceptable communication protocols are BACnet and Modbus. BAS shall be provided with the following metering points from the meter registers:
   1. Energy – kWh Total
   2. Current - per phase
   3. Voltage - per phase line-line and line-netural
   4. Power - Real, reactive, and apparent; 3-phase total
   5. Power factor - 3-phase average
   6. Frequency – 3-phase average

PART 2 - PRODUCTS

2.1 SERVICE METER

A. Service Meter:
   1. A service meter will be required on the secondary side of the service transformer for each building connected to campus electrical distribution, with the meter located at the main distribution panel. Meter shall have a local display. Projects may have unique design considerations that will require discussions with Facilities Operations Department engineering staff. Meter data communication must be coordinated with Building Automation System (BAS) – interface requirements provided by Siemens.
   2. Install meter by the manufacturer at the factory prior to shipping.
   3. Acceptable Manufacturers:
      a. Electro Industries Shark 200 (preferred)
      b. Eaton IQ Series
      c. GE EPM 2000 Series
2.2 SUB METER

A. Sub Meter:
   1. Submeter shall be required for metering of smaller loads within buildings or remote isolated campus loads.
   2. Acceptable Manufacturers:
      a. Electro Industries Shark 50B/100B BACnet enabled meter where wired Ethernet is available (preferred) or Electro Industries Shark 100S for wireless communication locations where wired Ethernet is not available
      b. Eaton IQ Series
      c. GE EPM 2000 Series
   3. Sub-metering is required but not limited to the following installations:
      a. Parking Lots
      b. Street Lighting
      c. Tenant Occupied Spaces
      d. Construction Trailers and Site
      e. LEED Measurement and Verification Requirements

2.3 HIGH PERFORMANCE METERING

A. Meter
   1. Metering of buildings containing highly sensitive research shall be accomplished with a high performance meter. High performance meters shall have advanced power quality capability and waveform recording functions.
   2. Install meter by the manufacturer at the factory prior to shipping.
   3. Acceptable Manufacturers:
      a. Electro Industries Nexus 1200 series
      b. Eaton Power Xpert 4000/6000/8000 series
      c. GE EPM 9000 series.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide all service and sub meters with hardware and software as needed for Bacnet interface to the BAS. Interface provided by Siemens.

B. Provide potential transformer, ratio and polarity tests and wiring checks.

C. Provide current transformer, ratio and polarity tests and wiring checks.

D. Refer to Section 23 09 93 for points list to be integrated with the BAS.

3.2 DISTRIBUTION SWITCHBOARD

A. Provide Kwh meters in all switchboard with 0.3 metering accuracy class.

B. Place metering in switchgear and protected by fusing and a disconnect.

C. Provide terminal blocks for wall wiring.

END OF SECTION 26 27 13
SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Plug-in type devices are not acceptable.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide wiring devices of one of the following:

1. Devices:
   a. Harvey Hubbell Inc.
   b. Leviton Mfg. Co.
   c. Pass and Seymour Inc.
   d. Bryant Electric Co.
   e. General Electric Co.

2. Wall (Local) Switches: Numbers used below are those of Hubbell. Equivalent Cooper, P & S, or Leviton.

3. Fire Rated Poke-through Receptacle: Hubbell systems or approved equal.

4. Multi-Outlet Assembly (MOA): Hubbell or Wiremold.

2.2 MATERIALS, GENERAL

A. Receptacles:

1. Duplex receptacles shall be of the heavy-duty type, NEMA 5-20 Reconfigurations. They shall be capable of being side or back wired, with clamp type terminals for back wiring. The grounding blades shall be aligned in such a manner that they are parallel to the longitudinal plane of the receptacle. Plus type receptacles are not permitted.

2. All duplex, single, and special receptacles shall be heavy duty, standard grade listed by Underwriter’s Laboratories, and have a single brass mounting strap with self-grounding and have a hex-head green grounding screw and be side and back wired. Each device shall bear the UL/FS Label.

3. Convenience Receptacle Configuration: NEMA WD 1; Type 5-20R.. All receptacles connected to emergency circuits shall have a red face. Color selection for normal devices shall be verified with Engineer prior to ordering.

4. Standby Receptacles: Single or duplex minimum 20-amp, color red.

5. Isolated Ground Circuit: Single or duplex minimum 20-amp, color orange, with isolated ground.


7. Telephone or CRT Receptacles: 4 inch square box with one gang plaster ring and 5/8 inch diameter grommet hole split plate.

8. Special Purpose Receptacles: Provide where shown on drawings. Standard grade, standard color, and of the appropriate code and NEMA configuration to match the supply circuit and load involved. Provide proper grounding through receptacle for equipment.

9. Fire Rated Poke-through: Provide where shown on drawings. Poke-through shall provide services as shown on drawings and have a carpet saver feature.

<table>
<thead>
<tr>
<th>Duplex</th>
<th>20A</th>
<th>125V</th>
<th>HBL5362</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplex – Isolated Ground Fault</td>
<td>20A</td>
<td>125V</td>
<td>GFR5362</td>
</tr>
<tr>
<td>Duplex – Isolated Ground</td>
<td>20A</td>
<td>125V</td>
<td>IG5362</td>
</tr>
<tr>
<td>Single</td>
<td>20A</td>
<td>125V</td>
<td>HBL5361</td>
</tr>
<tr>
<td>Single</td>
<td>30A</td>
<td>125V</td>
<td>HBL9308</td>
</tr>
</tbody>
</table>
WIRING DEVICES

<table>
<thead>
<tr>
<th>Single</th>
<th>20A</th>
<th>250V</th>
<th>HBL5652</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>30A</td>
<td>250V</td>
<td>HBL9330</td>
</tr>
<tr>
<td>Single</td>
<td>30A</td>
<td>125/250V</td>
<td>HBL9430A</td>
</tr>
</tbody>
</table>

**B. Switches:**
1. Wall Switches for Lighting Circuits: NEMA WD1; FS W-S-896E; AC, quiet type, specification grade, listed by Underwriter’s Laboratories with toggle handle, rated 20 amperes or greater at 277 volts AC, unless noted otherwise. Mounting straps shall be metal and be equipped with a green hex-head ground screw. Each switch shall bear the UL/FS Label.
2. Handle: Red for emergency power circuits. Verify color for normal power devices with Engineer prior to ordering.
3. Pilot Light Type: Lighted handle lit when switch is "on."
4. Locator Type: Continuously lighted handle.

<table>
<thead>
<tr>
<th>Switches</th>
<th>#</th>
<th>Amps</th>
<th>Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Pole</td>
<td>#1221</td>
<td>20</td>
<td>277</td>
</tr>
<tr>
<td>Three-Way</td>
<td>#1223</td>
<td>20</td>
<td>277</td>
</tr>
<tr>
<td>Four-Way</td>
<td>#1224</td>
<td>20</td>
<td>277</td>
</tr>
<tr>
<td>Switch with Pilot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Series 1200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**C. Wiring Device Accessories:**
1. Wall Plates: Provide Wall plates for single and combination wiring devices, of types, sizes, and with ganging and cutouts as indicated. Select plates which mate and match wiring devices to which attached. Construct with metal screws for securing plates to devices; screw heads colored to match finish of plates. Identify all wall plates used for receptacles with branch circuit number. Provide blank wall plates for all cable, data, telephone and junction and outlet boxes. Where cables are routed through the wall plate, provide grommets in wall plate openings to protect cables. Provide plates possessing the following additional construction features:

a. Material and Finish: Stainless steel smooth or match existing.

PART 3 - EXECUTION

3.1 **EXAMINATION**

A. Verify boxes are installed at proper height and openings are neatly cut and will be completely covered by wall plates.

B. Verify branch circuiting wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 **INSTALLATION, GENERAL**

A. Install wiring devices of type as indicated on drawings. All connections shall be made up tight and device set plumb. Use care in installing device in order to prevent damage to device and wire in outlet box. Install wiring devices as indicated, in accordance with manufacturer’s written instruction, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.

C. Install wiring devices only in electrical boxes that are clean; free from excess building materials, dirt, and debris.

D. Install wiring devices after wiring work has been installed and wall finishes have been completed. Install wall plates plumb and level, after painting work is completed. Provide a device plate for each outlet to suit device installed and install blank plates or covers for J-boxes and empty outlets.
E. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for wiring devices or as required per UL Standards 486A.

F. Upon installation of wall plates and receptacles, advise Contractor regarding proper and cautious use of convenience outlets. At time of Final Completion, replace those items that have been damaged, including those burned and scored by faulty plugs.

G. Provide equipment grounding connections for wiring devices, unless otherwise indicated.

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Refer to Standard Section 26 05 00 for testing, cleaning, and certification requirements.

B. Prior to energizing circuitry, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energization, test wiring devices to demonstrate compliance with requirements.

C. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

END OF SECTION 26 27 26
SECTION 26 32 13 - DIESEL ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Locate generators down wind taking into account the location of future buildings. Also if possible place generators on opposite side of building air intakes. Coordinate final location with the University Project Manager.

B. Provide lighting and receptacles on individual circuits inside and outside of the generator enclosure. Circuit lighting and receptacles to a standby panel.

1.2 SUBMITTALS

A. Drawings to indicate electrical characteristics and connection requirements. Show plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, required clearances, and electrical diagrams including schematic and interconnection diagrams.

B. Drawings showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, and remote radiator.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufactures: Subject to compliance with requirements, provide products by the following:
   1. Caterpillar
   2. Cummins
   3. Stewart & Stevenson

2.2 MATERIALS, GENERAL

A. Engine:
   1. Type: Water-cooled V-type, four stroke cycle, compression ignition Diesel (No. 2 fuel oil) internal combustion engine.
   2. Rating to equal the load and compensated for elevation with 70% overload for 1 hour.
   3. Governor: Isochronous type to maintain engine speed within 0.5 percent, steady state, and 5 percent, no load to full load, with recovery to steady state within 2 seconds following sudden load changes.
   4. Safety Devices: Engine shutdown on high water temperature, low oil pressure, over speed, and engine over crank. Limits as selected by manufacturer.
   5. Engine Starting: DC starting system with positive engagement.
   6. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F, and suitable for operation on 208 volts AC.
   7. Radiator: Radiator using glycol coolant, with blower type fan, sized to maintain safe engine temperature in ambient temperature of 110 degrees F. Radiator airflow restriction will be 0.5 inches of water maximum. Provide low-level indicator alarms.
   8. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil circulation pump, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine/generator control panel.
9. Mounting: Provide unit with suitable spring-type vibration isolators and mount on structural steel base.

B. Generator:
   1. Generator: NEMA MG1, three phase, four pole, re-connectible brushless synchronous generator with brushless exciter.
   2. Voltage Regulation: Include generator-mounted volts per hertz exciter-regulator to match engine and generator characteristics, with voltage regulation plus or minus 1 percent from no load to full load. Manual controls to adjust voltage drop, voltage level (plus or minus 5 percent) and voltage gain.
   3. AC Waveform Total Harmonic Distortion (THD), less than 3% for any single harmonic.
   4. Telephone Influence Factor (TIF), less than 50% per NEMA MG1-22.43.

C. Fuel Tank:
   1. Fuel Tank shall be sized to accommodate run times as required per code. All research laboratory buildings shall have tank sized for 24 hours minimum.
   2. Provide Integral Skid mounted belly tank. If tank size is too large to be skid mounted then coordinate above ground tank with the university.
   3. All tanks shall be double containment with leak detection.
   4. Below grade tanks are prohibited without prior approval from the University Project Manager.

D. Accessories:
   1. Exhaust Silencer: Critical type silencer, with muffler companion flanges and flexible stainless steel exhaust fitting, sized in accordance with engine manufacturer's instructions.
   2. Batteries: Heavy duty, diesel starting type lead-acid storage batteries, 24 volt system 240 ampere-hours minimum capacity. Match battery voltage to starting system. Include necessary cables and clamps.
   3. Battery Tray: Treated for electrolyte resistance, constructed to contain spillage. If in a cool area, provide heating pads.
   4. Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet NEMA 250, Type 1 requirements.
   5. Line Circuit Breaker: NEMA AB 1, molded case circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole, sized in accordance with NFPA 70. Include battery-voltage operated shunt trip, connected to open circuit breaker on engine failure. Unit mount in enclosure to meet NEMA 250, Type 1 requirements. Circuit Breaker to be 100% rated.
   6. Engine-Generator Control Panel: NEMA 250, Type 1 generator mounted control panel enclosure with engine and generator controls and indicators. Include provision for padlock and the following equipment and features:
      a. AC Output Voltmeter: 3.5-inch dial, 2 percent accuracy, with phase selector switch.
      b. AC Output Ammeter: 3.5-inch dial, 2 percent accuracy, with phase selector switch.
      c. Output voltage adjustment.
      d. Push-to-test indicator lamps, one each for low oil pressure, high water temperature, over speed, and over crank.
      e. Engine start/stop selector switch.
      f. Engine running time meter.
      g. Oil pressure gauge.
      h. Water temperature gauge.
      i. Auxiliary Relay: 3PDT operates when engine runs, with contact terminals pre-wired to terminal strip.
      j. Additional visual indicators and alarms as required by NFPA 110.
      k. Remote Alarm Contacts: Pre-wire SPDT contacts to terminal strip for remote alarm functions required by NFPA 110.
      l. Frequency Meter: 45-65 Hz. range, 3.5 inch dial.
7. Remote Annunciator Panel: Surface mounted panel with brushed stainless steel. Provide alarm horn, and indicators and alarms as follows:
   a. High battery voltage (alarm).
   b. Low battery voltage (alarm).
   c. Low fuel (alarm).
   d. System ready.
   e. Anticipatory-high water temperature.
   f. Anticipatory-low oil pressure.
   g. Low coolant temperature.
   h. Switch in off position (alarm).
   i. Over crank (alarm).
   j. Emergency stop (alarm).
   k. High water temperature (alarm).
   l. Over speed (alarm).
   m. Low oil pressure (alarm).
   n. Line power available.
   o. Generator power available.
   p. Lamp test and horn silence switch.

8. Building Automation System Interface: Provide interface to the BAS for all alarm points required to The Remote Annunciator panel.


PART 3 - EXECUTION

3.1 TESTING, CLEANING, AND CERTIFICATION

A. Provide full load test utilizing portable test bank for four hours minimum. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown and return to normal.

B. Record in 20-minute intervals during four hour test:
   1. Kilowatts.
   2. Amperes.
   3. Voltage.
   4. Coolant temperature.
   5. Room temperature.
   6. Frequency.
   7. Oil pressure.

C. Test alarm and shutdown circuits by simulating conditions.

END OF SECTION 26 32 13
SECTION 26 33 53 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS - UPS MODULE

A. Voltage. Input/output voltage of the UPS:
   1. Rectifier Input: 208 volts, three-phase, 4-wire-plus-ground
   2. Bypass Input: 208 volts, three-phase, 4-wire-plus-ground
   3. Output: 208 volts, three-phase, 4-wire-plus-ground

B. Output Load Capacity. Provide output load capacity at unity factor.

C. Scalable Output Capacity. UPS rated output capacity will be determined by design engineer.

1.2 DESIGN REQUIREMENTS – BATTERY

A. Battery Cells: Valve-regulated, lead acid batteries.

B. Reserve Time: 15 minutes.

C. Recharge Time: to 95% capacity within ten (10) times discharge time.

1.3 PERFORMANCE REQUIREMENTS

A. Voltage Configuration for Standard Units: 208V, three-phase, four-wire plus ground.

B. Voltage Range: +15%, -20% of nominal without derating.

C. Inrush Current: UPS inrush current not to exceed 1.5 times rated input current. Maintenance bypass and distribution cabinet inrush current not to exceed 8 times rated input current.

D. Current Limit: 140% of nominal AC input current maximum.

E. Current Distortion: <3% reflected THD maximum at full load.

F. Surge Protection: Sustains input surges without damage per criteria listed in IEC 1000-4-5.

G. Voltage Regulation:
   1. ±1% three-phase RMS average for a balanced three-phase load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature and load power factor
   2. ±5% three-phase RMS average for a 100% unbalanced load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature and load power factor

H. Frequency Slew Rate: Selectable from 0.1Hz/sec to 3.0Hz/sec maximum for single unit.

I. Phase Balance:
   1. 120 degrees ±1 degree for balanced load
   2. 120 degrees ±1.5 degrees for 100% unbalanced load

J. Voltage Distortion:
   1. <1% total harmonic distortion (THD) for linear loads
   2. <5% THD for 100% nonlinear loads (3:1 crest factor) without kVA/kW derating
K. Load Power Factor Range: 0.7 lagging to 0.9 leading without derating.

L. Overload Capability:
   1. 110% for 60 minutes
   2. 125% for 10 minutes
   3. 150% for 60 seconds

M. Voltage Transient Response: 100% load step, ±5.0%

N. Transient Recovery Time: to within 5% of steady state output voltage within half a cycle.

O. Voltage Unbalance: 100% unbalanced load, ±5%

P. Locate UPS in a conditioned space.

Q. Altitude: Provide UPS rating based on altitude derating factors.

1.4 MANUFACTURER QUALIFICATIONS

A. A minimum of 20 years’ experience in the design, manufacture and testing of solid-state UPS systems is required. The system shall be designed and manufactured according to world-class quality standards.

1.5 PROVIDE FACTORY TESTING PRIOR TO PRODUCT SHIPMENT.

PART 2 - PRODUCTS

2.1 FABRICATION

A. Materials
   1. Physically isolated control logic and fuses from power train components to ensure operator safety and protection from heat. All electronic components shall be accessible from the front without removing sub-assemblies for service access.

B. Wiring
   1. All electrical power connections shall be torqued to the required value and marked with a visual indicator.
   2. Provide tin-plated copper busbars.

C. Cooling
   1. Provide cooling capacity as needed to maintain manufacturer’s recommended operating temperature for the UPS and batteries.

2.2 COMPONENTS

A. General
   1. Provide on line, double conversion UPS.

B. DC Filter
   1. Provide DC filter with adequate capacity to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter without the battery connected.
2.3 INVERTER

A. Overload Capability
   1. Provide inverter be capable of supplying current and voltage for overloads exceeding 100% up to 150%. The UPS shall transfer the load to bypass when overload capacity is exceeded.

B. Voltage Distortion
   1. Total harmonic distortion in the output voltage will not exceed 1% for 0% to 100% linear loads.
   2. Total harmonic distortion in the output voltage will not exceed 4% for 0% to 100% non-linear loads.
   3. Total harmonic distortion in the output voltage will not exceed 5% for 0% to 100% non-linear, unbalanced loads.

2.4 DISPLAY AND CONTROLS

A. Monitoring and Control
   1. Provide microprocessor/graphical status display and controls. A graphical shall be used to show a single-line diagram of the UPS and shall be provided as part of the monitoring and controls sections of the UPS. Locate operator controls and monitors on the front of the UPS cabinet display. Monitoring functions such as metering, status and alarms on the graphical display. Additional features of the monitoring system shall include:
      a. Menu-driven display with pushbutton navigation
      b. Real-time clock (time and date)
      c. Alarm history with time and date stamp
      d. Memory with battery backup

B. Metering
   1. Display the following parameters:
      a. Input AC voltage line-to-line
      b. Input AC current for each phase
      c. Input frequency
      d. Battery voltage
      e. Battery charge/discharge current
      f. Output AC voltage line-to-line
      g. Output AC current for each phase
      h. Output frequency
      i. Apparent power
      j. Active power
      k. Battery time left during battery operation

C. Alarm Messages
   1. Display the following alarm messages:
      a. Mains Voltage Abnormal
      b. Mains Undervoltage
      c. Mains Freq. Abnormal
      d. Charger Fault
      e. Battery Reversed
      f. No Battery
      g. Control Power 1 Fail
      h. Parallel Comm. Fail
      i. Bypass Unable To Track
      j. Bypass Abnormal
      k. Inverter Asynchronous
      l. Fan Fault
      m. Control Power 2 Fail
      n. Unit Over Load
D. Status Messages
1. Display the following UPS status messages:
   a. Rectifier (Off / Soft Start / Main Input On / Battery Input On)
   b. Input Supply (Normal Mode / Battery Mode / All Off)
   c. Battery Self Test (True / False)
   d. Input Disconnect (Open / Closed)
   e. EPO (True / False)
   f. Charger (On / Off)
   g. Output Disconnect (Open / Closed)
   h. Maint. Disconnect (Open / Closed)
   i. Bypass Disconnect (Open / Closed)
   j. Inverter (Off / Soft Start / On)
   k. Bypass (Normal / Unable To Trace / Abnormal)
   l. Output Supply (All Off / Bypass Mode / Inverter Mode / Output Disable)
   m. Inverter On (Enable / Disable)

E. On-Line Battery Test
1. Provide the UPS with a menu-driven On-Line Battery Test feature. The test shall ensure the capability of the battery to supply power to the inverter while the load is supplied power in the normal mode.

2.5 STATIC TRANSFER SWITCH

A. General
1. Provide a static transfer switch and bypass circuit as an integral part of the UPS.

2.6 BATTERY POWER PACK

A. Provide the battery power pack valve-regulated, lead-acid battery cells housed in a separate cabinet that matches the UPS cabinet styling to form an integral system lineup. Provide battery cells on slide-out trays for ease of maintenance. Provide a battery disconnect circuit breaker for isolation of the battery pack from the UPS module.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide central UPS circuits for power feeding facilities Building Automation System (BAS) control panels. Circuiting building user loads to this UPS is not acceptable.

B. Provide central UPS circuits for power feeding animal facility lighting control computer and control panels associated with watering systems, robotics, cage wash, mechanical systems, etc.

C. During the design process, coordinate with the facilities department any additional building systems required to be connected on the UPS.

END OF SECTION 26 33 53
SECTION 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Air terminal maximum size 24”. Install Per UL Master label requirements.

B. Down-lead conductors to be routed in PVC conduit. Minimum size one-inch.

C. Install a lightning protection loop around the building perimeter. Locate within 3'-0" of the building. Minimum size to match the down lead conductor.

D. Install ground rods Per UL Master label requirements.

E. Bond columns to the roof lightning protection cable and underground lightning protection loop as required per NFPA.

F. Each individual system (building) shall be UL Master labeled.

G. Except for special environments, all material shall be copper and bronze.

1.2 SUBMITTALS

A. Shop Drawings: Indicate layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details. Include mounting detail of air terminals and conductors.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in lightning protection equipment with minimum three (3) years documented experience and member of the Lightning Protection Institute.

B. Installer: Authorized installer of manufacturer with minimum three (3) years documented experience and certified by the Lightning Protection Institute.

C. Obtain the services of Underwriters Laboratories, Inc. to provide inspection and labeling of the lightning protection system in accordance with UL 96A.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Thompson Lightning Protection, Inc.
   2. American Lightning Rod Co.
   3. Capitol Lightning Protection Co., Inc.
   4. Independent Protection Co., Inc.

2.2 MATERIALS, GENERAL

A. Product Listing: UL 96 – Master Cable

PART 3 - EXECUTION
3.1 INSTALLATION, GENERAL

A. Connect conductors using mechanical connectors above grade and exothermic welding process below grade. Protect adjacent construction elements and finishes from damage.

B. Bond exterior metal bodies on building to lightning protection system.

END OF SECTION 26 41 13
SECTION 26 51 00 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. General Information:
1. Lighting design shall take into consideration for fixture maintenance and lamp replacement. Fixtures shall be accessible from a standard ladder located on a level floor or landing.
2. Lighting Requirements:
   a. General:
      1) Provide energy efficient fluorescent luminaries wherever possible.
      2) Lamps shall be 4100K unless requested otherwise. Minimum CRI is 82.
      3) Luminary installations must comply with requirements set forth in other sections of this Division 26.
      4) Provide emergency and exit lighting per NFPA, IBC and NEC requirements and recommendations. Exit lights should be LED type.
      5) If emergency generator circuits are not available, provide emergency lighting battery packs in elevator machine rooms, mechanical rooms electrical rooms. Fire, Security rooms and Egress Lighting per Fire Code.
      6) Use Alto Low Mercury lamps wherever possible.
      7) Provide 2 ballasts in 3 and 4 lamp luminaries for compatibility with tandem wiring.
      8) Refer to current edition of the IES for lighting levels in areas not included in the following paragraphs.
      9) Electronic ballasts to be low inrush current type.
      10) Provide fluorescent luminaries with energy efficient electronic ballast, less than 10% THD. Provide luminaries with RIF ballasts in sensitive areas. As determined by the university.
      11) Provide energy star rated LED fixtures for difficult to reach areas including, but not limited to, atriums, stairs, auditoriums, etc.
   b. Corridors:
      1) Minimum foot-candle level in corridors shall be 20 foot candles.
      2) Minimum foot-candle level in lobbies shall be 15 foot-candles.
      3) The university standard corridor lighting consists of 2-lamp, 2’x4’ recessed luminary with perforated shields on each side, and consistent with current LEED design.
   c. Offices:
      1) Minimum foot-candle level shall be 30 foot-candles. Offices that require detail work at their desk shall be provided with minimum of 50 foot-candles. Rooms with special VDT requirements may be provided with less than 30 foot-candles, either with a dual switching option or Dimming Ballast as determined by the university.
      2) The university standard office lighting consists of 3-lamp, 2’x4’ recessed luminary with 3” deep parabolic lenses.
   d. Laboratories:
      1) Minimum foot-candle level shall be 75 or current NIH Standards whichever is higher. This light level shall be achieved without the use of task lights.
   e. Classrooms:
      1) Minimum foot-candle level shall be 40.
      2) Computer classrooms shall be provided with pendant-mounted indirect luminaries. Luminaries shall be mounted with aircraft cable. Maximum length of steel indirect product shall be 12’-0”. Minimum foot-candle level shall be 25.
      3) Laboratory classrooms: Minimum foot-candle level shall be 75.
      4) Coordinate fixture type with ceiling projectors as needed. Fixture location shall not obstruct projector.
f. Equipment Rooms:
   1) Provide a minimum of 3 foot-candles on vertical surfaces and 30 footcandles at 30” high horizontal surfaces.

g. Lecture Halls/Auditoriums:
   1) Lighting shall be dimmed fluorescent or LED.
   2) Lighting zones and control locations shall be coordinated with the university prior to final construction drawings.
   3) Lighting design shall take into consideration for fixture maintenance and lamp replacement. Review fixture accessibility with the University Project Manager prior to Design Completion.

h. Exit/Egress Lighting:
   1) Provide adequate exit/egress lighting per code requirements.
   2) Coordinate with the university project manager if the egress fixtures are to be controlled with the normal adjacent fixture or if they are to be used as night lights.

i. Dark Rooms:
   1) Provide local manual controls for dark room light fixtures.

j. Outdoor Lighting
   1) Outdoor lighting should be zoned to provide flexibility for safety and economy.

k. Animal Facilities
   1) Provide dual level lighting in all holding rooms. Provide 30 foot-candles at half level and 60-70 foot-candles at full “On”.
   2) Provide red filter on one lamp controlled separately in all holding rooms which eliminates wave lengths visible to animals, verify with the university.
   3) Provide surface mounted, lensed “wash down” and gasketed fixtures throughout the facility.

l. Janitor Closets
   1) Provide Stonco vapor tight fixture with guard.

1.2 SUBMITTALS

1.3 Product Data: Submit product data with mounting type and installation instructions for each proposed types of luminary and accessories.

A. Deliver luminaries in factory-fabricated containers or wrappings, which properly protect them from damage.

B. Store luminaries in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat, and blocked off ground.

C. Handle luminaries carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

PART 2 - PRODUCTS

2.1 MANUFACTURES

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Ballasts:
      a. Motorola
      b. Advance
      c. Universal
      d. Osram
2.2 MATERIALS, GENERAL

A. Provide low-energy fluorescent lamp ballasts, capable of operating lamp types indicated; with high power factor, rapid-start, and low-noise features; Type 1, Class P; sound-rated A. Total Harmonic Distortion shall be less than 10%.

B. Wiring: Provide electrical wiring within luminary suitable for connecting to branch circuit wiring as follows:
   1. NEC Type THHN for 120 volt, minimum #18 AWG
   2. NEC Type THHN for 277 volt, minimum #18 AWG
   3. Provide a green grounding wire in flexible conduit connection to all recessed fixtures. Provide green grounding wire to all power outlets. Provide green grounding wire in all runs from panels to fixtures and devices.

C. Provide ballasts with low in-rush current where possible.

D. Ballast shall have a power factor of 0.98 or higher and shall have a ballast minimum efficiency of 90%.

E. Lenses: Diffusers for fluorescent fixtures shall be acrylic A12.125.

F. Exit Signs: Housing shall be extruded aluminum. Face shall be translucent white with green lettering. Directional arrows shall be universal for field adjustment. Mounting shall be as indicated on project drawings. Battery shall be provided if an emergency source is not available. Lamp shall be LED type. Input voltage shall be as shown on drawings. H-3 radioactive exit signs must not be specified.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which lighting is to be installed, and substrate for supporting lighting. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION, GENERAL

A. Install lighting at locations and heights as indicated, in accordance with manufacturer’s written instructions, applicable requirements of NEC, NECA’s “Standard of Installation,” NEMA standards, and with recognized industry practices to ensure that lighting fulfills requirements.

B. Provide luminaries and/or outlet boxes with hangers to properly support luminary weight. Comply with IBC luminary support requirements.

C. Install flush-mounted luminaries properly to eliminate light leakage between frame and finished surface.

D. Provide plaster frames for recessed luminaries installed in other than suspended grid-type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.

E. Fasten luminaries securely to indicate structural supports; and ensure that pendant luminaries are plumb and level. Provide individually mounted pendant luminaries longer than 2 feet with twin hangers. Mount continuous rows of luminaries with one more aircraft cable support greater than number of luminaries in the row.

F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s
torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B, and the National Electrical Code (NEC).

G. Provide additional supports for all surface-mounted luminaries greater than 2 feet in length in addition to the outlet box.

H. Overall dimensions of incandescent or fluorescent fixtures recessed in suspended grid ceilings shall be such that they will fit into grid ceiling with no distortion or field repair to fixtures and with no distortion of ceiling grids. If field repair is required, the engineer shall be notified immediately. All fixtures must be supported independent of the ceiling grid per NEC. Coordinate installation of the fixtures with installer of ceiling so that ceiling will be absolutely level after completion.

I. Grounding: Provide equipment-grounding connections for lighting as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

J. Install exit signs per manufactures recommendations.

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Clean luminaries of dirt and construction debris upon completion of installation, and again prior to project turnover. Clean fingerprints and smudges from lenses.

B. Protect installed luminaries from damage during remainder of construction period.

C. At Date of Final Completion, replace lamps in luminaries that are observed to be noticeably dimmed after Contractor’s use and testing, as judged by Engineer.
   1. Refer to Division 1 sections for the replacement/restoration of lamps in lighting where used for temporary lighting prior to Date of Final Completion.

END OF SECTION 26 51 00
SECTION 26 56 00 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Meet light levels and uniformity ratios as recommended by IESNA recommended practice manual: Lighting for Exterior Environments (RP-33-99).

B. All luminaries with more than 3500 initial lamp lumens must be full cut off.

C. Exterior area and site lighting shall be included in campus exterior lighting wireless control system.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer’s product data with mounting type and installation instructions on each proposed type of luminary and accessories.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver lighting in factory-fabricated containers or wrappings, which properly protect luminaries from damage.

B. Store lighting in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, laid flat, and blocked off ground.

C. Handle lighting carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Open Parking Lots and Street Lighting:
   a. Campus Standard Fixture – Gardco Form 10 Round LED Arm Mount:
      1) CA22L; light distribution depends on whether single or double configuration and location, use Q or 3 distribution; 277v, 110W LED, 3000K, 80 CRA, 0-10V dimming, wireless communication; finish to be campus standard color RAL7038. Pole: RA5, 30 ft high, fixed base, accommodates single or double configuration as required, finish color RAL7038
      b. General Description: Pole mounted, aluminum type luminary (single and double-head), thirty (30) foot aluminum pole, both with optional color paint (RAL7038), DLC listed

2. General Campus Lighting:
   a. Campus Standard Fixture– Gardco Form 10 Round LED Post Top Mount:
      1) MP17L; P12 yoke fitter; light distribution depends on location, use Type 5 distribution; 277v, 70W LED, 3000K, 80 CRA, 0-10V dimming, wireless communication; finish to be campus standard color RAL7038. Pole: RA4, 10 ft high, fixed base, finish color – RAL7038.
      b. General Description: Pole-mounted, aluminum type luminary with solid top (single head), ten (10) foot aluminum pole, both with optional color paint – RAL7038, DLC listed

3. Exterior of Building Walls, Above Entries (Fixtures can be specified per building):
   a. Primary Manufacturer – Philips Stonco LPW16 Small Wall Sconce
b. General Description: Rectangular aluminum type, wall mounted small wall sconce, 12 inch, anodized, color bronze, 277 volt, 40W LED max, 4000K, DLC listed
c. Other fixtures as approved per location

4. Exterior at Colonnades:
   a. Primary Manufacturer – Philips Stonco LPW7 Small Wall Sconce;
   b. General Description: Rectangular aluminum type, wall mounted small wall sconce 8 inch, anodized, color bronze, 277 volt, 14W LED max, 4000K, DLC listed
c. Other fixtures as approved per location

5. Exterior at service yards:
   a. Primary Manufacturer – Philips Stonco LPW32 Small Wall Sconce:
   b. General Description: Wall mounted full cut-off, aluminum housing dark bronze finish, 12 inch, 277 volt, 71W LED max, 4000K, DLC listed
c. Fixture style as appropriate for location; Wall-PAK used only with prior approval

6. Accent Lighting Near Walkways:
   a. Primary Manufacturer – Gardco BR841 Bollard LED (head only)
      1) 8 inch diameter, campus standard finish – RAL 7038
   b. General Description: Concrete bollard mounted (provided by others), cylindrical, aluminum luminary, 8 inch diameter, painted aluminum, 360 degree distribution, full cutoff, 277 volt, 26W LED max, DLC listed
c. Other fixtures as approved per location

7. Landscape Areas:
   a. Type GM2: Hydrel, PINE 9LED38, provide with stem.
   b. General: Ground-mounted aluminum adjustable LED up light stemmed up in plant areas. Integral components including electrical parts, lamps, and optical assembly are totally enclosed, rain tight, dust tight, and corrosion resistant. Dark bronze baked enamel finish. Narrow Flood, 3000K., DLC listed

8. Pole Bases:
   a. Concrete pole bases shall be designed by Licensed Colorado Structural engineer for wind loading. Each pole base shall have its own ground rod bended to the base rebar.

9. Parking Garage:
   a. Primary Manufacture – Gardco “Garage Lighting – G3 LED”.
      1) G3 LED Standard Luminaire, Type 5 symmetrical distribution, 2 LED arrays, 73W max, 4000K, 75 CRI, UNIV (277V) volt, 0-10V dimming, wireless communication,
   b. General Description – Surface mounted, die cast aluminum canopy, DLC listed.

10. In grade well lights are prohibited.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which lighting is to be installed. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION, GENERAL

A. Install lighting at locations and heights as indicated, in accordance with manufacturer’s written instructions, applicable requirements of NEC, NECA’s “Standard of Installation,” NEMA standards, and with recognized industry practices to ensure that lighting fulfills requirements.

B. Fasten luminaries securely to structural supports and ensure that luminaries are plumb and level.

C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s
torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B, and the National Electrical Code (NEC).

D. Grounding: Provide equipment-grounding connections for lighting as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds. Any connection below grade and not accessible shall be of CAD Weld type (non-reversible).

3.3 TESTING, CLEANING, AND CERTIFICATION

A. Clean lighting of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses.

B. Protect installed luminaries from damage during remainder of construction period.

C. At Date of Final Completion, replace lamps in luminaries, which are observed to be noticeably dimmed after Contractor’s use and testing, as judged by Engineer.
   1. a. Refer to Division 1 sections for the replacement/restoration of lamps in lighting where used for temporary lighting prior to Date of Final Completion.

D. Upon completion of installation of lighting and after circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then re-test to demonstrate compliance; otherwise, remove and replace with new units and proceed with re-testing.

END OF SECTION 26 56 00
SECTION 27 00 00 - COMMUNICATIONS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. This section describes the codes, standards, specifications, recommendations, and practices required for construction at The University of Colorado Denver | Anschutz Medical Campus for the Information Technology (IT) Services department. Section 27 00 00 applies to all telecommunications projects at The University.

B. The project general contractor (GC) is responsible for building telecommunications pathways and spaces as per the requirements described in this document. The project GC shall provide these specific items: spaces (telecommunications rooms, telecommunications entrance faculty, and equipment rooms), pathways (riser and horizontal distribution), grounding system, and fire suppression systems, as described below. The IT Services department is responsible, through its contractor, for providing cabling, data networking, and voice equipment.

C. Planning.
   1. To facilitate provisioning of telecommunications services, the architect/engineer shall provide the University IT Services with floor plan drawings for new building construction and major renovation projects during design and at construction. CAD drawings of the Electrical/Communications plans shall be provided to IT Services upon release of construction document through the The University project manager.
   2. The project’s technology consultant shall meet with the building’s projected occupants, IT Services Network Services, and IT Services Telecommunications, and other interested parties to determine the telecommunications requirements of the occupants. Compliance with overall campus telecommunications plans will also be validated during these meetings. The technology consultant shall submit all findings to IT Services for review and approval.
   3. The preliminary plans, indicating service locations and space requirements, will be returned to project managers for inclusion in the final plans.

D. Consult with The University IT Services for the following.
   1. Acceptability for specific substitutions of specified products.
   2. Guidance in the application of a standard or specification in a non-listed or design situation.
   3. Approval for deviation from standards and specifications or industry-standard methods and procedures if indicated by special circumstances.

E. Workmanship. All materials and equipment shall be installed in accordance with recommendations of the manufacturer as approved by the architect, to conform to initial design requirements or specification’s and contract documents.

1.3 SUBMITTALS

A. Refer to Section 27 05 00 for requirements.
1.4 QUALITY ASSURANCE

A. Applicable Codes, Standards, and Specifications: The following list of codes, standards, specifications, recommendations, and methods and procedures (M&P) are applicable to the provisioning of telecommunications services for The University. They are incorporated by reference.

2. ANSI/EIA/TIA-568-C.0: Generic Communications Cabling for Customer Premises.
11. ASTM: American Society for Testing and Materials
18. ICEA: Insulated Cable Engineers Association
19. IEEE-802.11 a, b, g, n: Wireless Local Area Networks
20. IEEE-802.3: 10Mb/s, 100Mb/s, 1Gb/s, and 10Gb/s Ethernet Standards as applicable based on media types (twisted pair copper, fiber optics, etc.)
21. IEEE-802.3ak: 10Gb/s Ethernet (evolving copper standard).
22. IEEE-802.3af: Power-over-Ethernet (PoE).
24. IEEE-141: Recommended Practice
27. NESC: National Electrical Safety Code
28. NEMA Stds Pub No. VE 1, Cable Tray Systems. Additionally, comply with current edition of NEC, as applicable to construction and installation of cable tray systems.
29. NEMA Std 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
32. UL Compliance: Provide products which are UL-listed and labeled.

B. Requests for variations from code shall be submitted to the The University Code Official via the University project manager and must have IT Services approval. The University Code Official will either disapprove or approve the request. In general, requests for code variations shall not be looked upon favorably. Variations from standards may be authorized by the University IT Services on a case-by-case basis and must be requested in writing by the designer through the University project manager.

C. The University owns and maintains its telephone and communications distribution system. The University IT Services will provide design parameters for the distribution systems and for systems in individual
buildings, and IT Services shall be consulted during project design through the assigned the University project manager.

1.5 DEFINITIONS

A. Telecommunications. Any transmission, emission, or reception of signs, signals, writings, images, and sounds, or information of any nature by wire, radio, visual, or other electromagnetic systems. Includes, but is not limited to, voice communications networks, Local Area Networks (LAN), Wide Area Networks (WAN), and Local Exchange Carriers (LEC).

B. Telecommunications Room (TR). A floor serving facility for housing telecommunications equipment, cable terminations, cross-connections, and network electronics. The TR is the recognized transition point between the building backbone and the horizontal pathway facilities.

C. Equipment Room (ER). A campus serving space. An ER houses primary system electronics, power, and media distribution for a campus or groups of buildings. The Communications Center in Building 500 is an example of a campus serving ER. ERs require extensive planning due to their size, nature, scope, and complexity. ERs are not typically required for most projects.

D. Telecommunications Entrance Facility (TEF). Serves as the entry point into a building for the campus backbone media. TEFs interconnect the building backbone to campus backbone. The TEF is where conductive copper media receives its primary protection from sustained hazardous voltages. Therefore, significant wall space in the TEF may be required for primary protection of copper circuits. Also called the Service Entrance (SE).

E. Telecommunications Main Grounding Busbar (TMGB). The building’s main telecommunications grounding point. The TMGB is busbar placed in the TEF, ER, or a selected TR to provide interconnection to the building’s power ground via a bonding conductor for telecommunications.

F. Telecommunications Grounding Busbar (TGB). A common point of connection for telecommunications systems and equipment for bonding to ground. TGBs are required in all TRs and ERs.

G. Telecommunications Bonding Backbone (TBB). A conductor that electrically interconnects the TMGB to all TGBs.

H. Grounding Equalizer (GE). A conductor used to interconnect two or more vertical TBBs in multistory buildings. Previously called a Telecommunications Bonding Backbone Interconnecting Bonding Conductor (TBBIBC).

I. Network. Backbone media and electronics for transport of electronic information between campus entities.

J. Horizontal Distribution. The facility used for installation of media from the TR to the work area. Usually consists of cable tray and J-hooks to the work area faceplate.

K. Work Area (WA). A building space where the occupant generally interacts with the telecommunications equipment. WAs are typically defined as 100 ft² of usable space.

L. Building backbone. The pathways between floors for distribution of media. Building backbone was previously called riser cabling.

M. Campus backbone. The pathways and media that provide connectivity between the Communication Center in Building 500 and all other buildings on the Anschutz Medical Campus (AMC). The campus backbone provides connectivity between buildings. The campus backbone represents the outside plant (OSP) infrastructure.
N. The University Information Technology (IT) Services. Department responsible for telecommunications on the University of Colorado at Denver and Health Sciences Center (the University) campuses.

O. Technology Consultant. A firm or member of a firm that has considerable technology design experience and possesses working knowledge and subject matter expertise in telecommunications code (NEC and NESC), industry standards (see TIA/EIA commercial standards in references), and BICSI methods and procedures (Telecommunications Distribution Methods Manual, LAN Design Manual, and Customer-Owned Outside Plant Design Manual).

1. IT Services maintains a list of pre-screened technology consultants that can be obtained from the the University project manager via IT Services.

2. Technology consultants used for the University projects shall be selected from the pre-screened technology consultant list.

3. Technology consultants not listed on the pre-screened technology consultant list must meet with IT Services for certification and possible inclusion on the list. Firms vying for campus technology consultant designation must possess a registered communication distribution designer (RCDD) on staff. The RCDD must be thoroughly familiar with campus standards and methods and procedures and be dedicated to the assigned project. Contact the IT Services Director of Communications (303.724.0440) for possible interview times.

PART 2 - DESIGN REQUIREMENTS

2.1 SPECIFIC DESIGN SPECIFICATION AND CONSTRUCTION REQUIREMENTS

A. Telecommunications Entrance Facility (TEF) or Service Entrance (SE).

1. All buildings require a TEF. The TEF serves as the entry point into a building for the campus backbone media. TEFs interconnect the building backbone to the campus backbone. The TEF shall be solely dedicated to telecommunications services. Space shall not be shared with electrical installations other than those designed and intended for telecommunications. The TEF shall be vertically aligned or stacked with the TRs to facilitate interconnection with the floors above and below. The University IT Services must be consulted if the TEF does not align with the building’s TRs.

2. TEFs may be co-located inside TRs or ERs, depending on the size of the building they support. Buildings larger than 100,000 ft² may require a dedicated TEF. Buildings with 5 or more stories shall have a shared TR/TEF that is 10’ x 16’. That is, TRs serving as the TEF shall be a minimum of 10’ x 16’. These larger TEFs shall support 5 equipment racks, with one rack being dedicated to fiber optics cable management. TEF ceiling height shall be a minimum of 8’ 6”.

3. The TEF shall be dry and free from the danger of flooding. The TEF shall not be located where water ingress is possible or probable. No water or drain piping shall be routed through the TEF that is not associated with TEF equipment. Steam, heat, and any other source of environmental hazard shall be avoided.

4. TEF location should be carefully considered. Accessibility for the delivery of equipment as well as expansion should be provided for. TR location must also be designed for maximum cable lengths as specified in associated documents listed in References.

5. The TEF location should not be adjacent to any source of electromagnetic interference (EMI). The TEF shall be located away from sources of EMI at a distance which will reduce the interference to 3.0 V/m throughout the deployed frequency range. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Bandwidth for telecommunications is up to 350 MHz.

6. Typical equipment requirements have a temperature range from 64°F to 75°F (18°C to 24°C) with a desired non-condensing, relative humidity range from 30% to 55%. Humidifiers are not typically required in TEFs. Consult IT Services for TEF cooling requirements.

7. The TEF is where conductive copper media receives it primary protection from sustained hazardous currents. Therefore, significant wall space in the TEF may be required for primary protection of copper circuits. All four TEF walls shall be covered by 3/4” non-combustible A/C plywood mounted 6” above the finished floor (AFF) to 8’6” AFF. (To see a sample of A/C fire rated plywood, contact Strait Lumber 11150 E. Colfax Avenue, Aurora CO or equivalent lumber
supplier 303.366.3561; description: 4x8-23/32” AC Fire Retard Ply PLY34ACNC). The A-side 
(smooth side) of the sheet shall be outward facing. The A/C plywood shall be securely fastened to 
the wall.

8. TEF design must conform to vibration requirements specified in TIA/EIA–569.

9. The TEF lighting shall be a minimum of 500-lux (50 foot-candles) measured 1 meter from the 
finished floor and shall be mounted to meet the design configurations of the room. Emergency 
lighting is recommended.

10. The TEF door shall be a minimum of 36” wide and 80” high, without doorsill, hinged to open 
outward, unless restricted by building code, and fitted with a lock compliant with IT Services and 
Facilities assigned key codes.

11. Floors, walls, and ceiling shall be treated and sealed to eliminate dust. Finish shall be light in color 
to enhance room lighting. Antistatic flooring materials shall be used.

12. All TEF ceilings shall be a minimum of 8’ 6” high, unobstructed; to provide space over the 
equipment frames for suspended cable trays or ladder racks. Suspended cable trays and ladder 
racks are typically installed at 7’ AFF. TEFs shall be free of false or suspended ceilings. Ceiling 
protrusions (i.e. fire suppression sprinkler heads) must be placed to assure a minimum of 8 feet of 
clearance from the finished floor.

13. A dedicated electrical panel shall be placed in each TEF to support telecommunications 
equipment. The panel shall be rated at 100 Amps or higher to facilitate future growth. The panel 
may not be shared, it is for the exclusive use of the TEF’s equipment. Emergency generator power 
is required for the TEF, if available in the project. Label the panel per campus standard.

14. A minimum of three (3) dedicated, unswitched 20A, 120-VAC duplex outlets, each on a separate 
circuit, shall be provided for equipment power at heights and locations specified by IT Services 
during the design phase. These three dedicated circuits shall be installed from above into the 
equipment racks as directed by IT Services. Additional convenience duplex outlets, on a separate 
dedicated unswitched circuit, should be provided at 6’ intervals around the room. Install the 
convenience receptacles 15” AFF or as directed by IT Services. Label all outlets to the campus 
standard. Emergency generator power is required for the TEF, if available in the project.

15. Sleeves or slots through walls and floors shall be fitted with approved re-enterable firestopping. 
Applicable codes, standards, and specifications shall be enforced.

16. Building backbone pathways connecting the TEF to TRs will require a minimum of four Trade 
Size 4” sleeves/conduits for interconnection, except where cable tray exists. A minimum of two 
(2) spare conduits must be installed when the TEF is not vertically aligned from floor-to-floor to 
allow for lower fill ratios.

17. Sprinkler heads shall be provided with wire cages to prevent accidental discharge. Preaction 
sprinklers are preferred over wet pipe or dry pipe systems. If wet pipe or dry pipe systems are 
employed, then drainage troughs shall be provided under the sprinkler heads and pipes to prevent 
leakage onto the TEF equipment. High temperature heads are preferred.

B. Telecommunications Room (TR).

1. A minimum of one TR shall be designated per floor and that TR shall be solely dedicated to 
telecommunications services. Space shall not be shared with electrical installations other than 
those designed and intended for telecommunications. TRs shall be vertically stacked to facilitate 
interconnection with the floors above and below.

2. The TR shall be dry and free from the danger of flooding. The TR shall not be located where water 
ingress is possible or probable. No water or drain piping shall be routed through the TR that is not 
associated with TR equipment. Steam, heat, and any other source of environmental hazard shall be 
avoided.

3. The minimum TR size is 10’ x 12’. Ceiling height shall be a minimum of 8’ 6”. Variations in size 
shall be approved by IT Services on a case-by-case basis and will be dependent upon the floor size 
and applications to be served.

4. TRs shall be designed to meet floor loading (minimum floor loading of 50 lbf/ft2) as specified in 
the references section.

5. TR location should not be adjacent to any source of EMI. The TR shall be located away from 
sources of EMI at a distance which will reduce the interference to 3.0 V/m throughout the
deployed frequency range. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Telecommunications bandwidth is up to 350 MHz.

6. TRs require a temperature range from 64°F to 75°F (18°C to 24°C). The desired non-condensing, relative humidity range is from 30% to 55%. Humidifiers are not typically required in TRs. Temperature sensors shall be configured for alarm reporting and HVAC support units shall be installed on emergency power. A minimum of one air change per hour is required. Each TR supports 4 racks of equipment, with each rack requiring 5,000 BTUs of cooling. Fan coil units are the required cooling source.

7. All four TR walls shall be covered by 3/4" non-combustible A/C plywood mounted 6” AFF to 8’6” AFF. (To see a sample of A/C fire rated plywood, contact Strait Lumber 11150 E. Colfax Avenue, Aurora CO 303.366.3561; description: 4x8-23/32” AC Fire Retard Ply PLY34ACNC). The A-side (smooth side) of the sheet shall be outward facing. The plywood shall be securely fastened to the wall.

8. TR design must conform to vibration requirements specified in TIA/EIA−569.

9. The lighting shall be a minimum of 500-lux (50 foot-candles) measured 1 meter from the finished floor and shall be mounted to meet the design configurations of the room. Emergency lighting is desired.

10. The TR door shall be a minimum of 36” wide and 80” high, without doorsill, hinged to open outward, unless restricted by building code, and fitted with a lock compliant with IT Services and Facilities assigned key codes.

11. Floors, walls, and ceiling shall be treated and sealed to eliminate dust. Finish shall be light in color to enhance room lighting. Antistatic flooring materials shall be used.

12. All TR ceilings shall be a minimum of 8’6” high, unobstructed; to provide space over the equipment frames for suspended cable trays or ladder racks. Suspended cable trays and ladder racks are typically installed at 7’ AFF in TRs. TRs shall be free of false or suspended ceilings. Ceiling protrusions (i.e. fire suppression sprinkler heads) must be placed to assure a minimum of 8 feet of clearance from the finished floor.

13. A dedicated electrical panel shall be placed in each TR to support telecommunications equipment. The panel shall be rated at 100 Amps or higher to facilitate future growth. The panel may not be shared, it is for the exclusive use of the TR’s equipment. Emergency generator power is required for all TRs, if available in the project. Label the panel per campus standard.

14. A minimum of two dedicated, unswitched 20A, 120-VAC duplex outlets, each on a separate circuit, shall be provided for equipment power at heights and locations specified by IT Services. These two dedicated circuits shall be installed from above into the equipment racks as directed by IT Services. These two unswitched circuits shall be homed from the dedicated panel described above. Additional convenience duplex outlets, on a separate dedicated unswitched circuit, should be provided at 6’ intervals around the room. Install the convenience receptacles 15” AFF or as directed by IT Services. Label all outlets to the campus standard. Emergency generator power is required for each TR, if available in the project.

15. Sleeves or slots through walls and floors shall be fitted with approved re-enterable firestopping. Applicable codes, standards, and specifications shall be enforced.

16. Building backbone pathways connecting TR’s will require a minimum of four (4) Trade Size 4” sleeves/conduits for interconnection, except where cable tray exists. A minimum of two (2) spare conduits must be installed when TR’s are not vertically aligned from floor-to-floor to allow for lower fill ratios.

17. Sprinkler heads shall be provided with wire cages to prevent accidental operation. Preaction sprinklers are preferred over wet pipe or dry pipe systems. If wet pipe or dry pipe systems are employed, then drainage troughs shall be provided under the sprinkler heads and pipes to prevent leakage onto the TR equipment. High temperature heads are preferred.

C. Equipment Room (ER).

1. ERs are not required for most buildings; contact IT Services for need and placement.

2. Generally, each campus requires a minimum of one ER. Buildings may require an ER if they are located at some significant distance from the Communications Center in Building 500. The IT Services department will specify when an ER is required. ERs shall be exclusively dedicated to telecommunications services. ER space must not be shared with electrical services other than those
designed and intended for telecommunications. The ER should be centrally located to minimize the size and length of backbone cabling as well as provide easements and pathways for backbone and carrier services required of the room. The room shall not be adjacent to any high-voltage electrical services or water mains. A location should also be selected to allow for movement of large or heavy equipment. Access to cable pathways are required. ER walls should extend to structure and provide a sealed environment for equipment.

3. The ER may also serve as the TEF facility for local exchange carriers (LEC) or competitive local exchange carrier (CLEC) where such a separate facility does not exist. Adjacency to existing carrier entrance facilities is required.

4. Sizing of ER will be calculated using area of service, types of service provided, and projections of growth. IT Services design engineers will provide space requirements based on these factors. The minimum size of an ER is 150 ft². Working clearances of 3 feet must be provided for all scheduled and installed equipment.

5. ERs may require access (raised) flooring to allow for the cable routing from cable vaults to equipment frames and PBX equipment. Cable tray, or equivalent, must be provided for cable management under the raised floor. Finished floor height must be at least 12” from the sub-floor to accommodate the cable management systems. The plenum area may be used for air handling for equipment cooling. All metal parts of the raised floor must be bonded to ground. Floor panels must be covered with high-pressure laminate or a durable, vinyl tile resistant to static electricity.

6. Floor loading capacity shall be sufficient to bear both the distributed and concentrated load of the installed equipment. The ER distributed loading shall be at least 100 lbf/ft² and the concentrated loading must be at least 2000 lbf. Distributed floor loading may range as high as 250 lbf/ft².

7. ER design must conform to vibration requirements specified in TIA/EIA−569.

8. ERs shall be dry and free from the danger of flooding. The ER must not be located where water ingress is possible or probable. No water or drain piping shall be routed through the ER that is not associated with ER equipment. Steam, heat, and any other source of environmental hazard shall be avoided.

9. The floors, walls, and ceilings shall be treated and sealed to eliminate dust.

10. All four walls in the ER shall be covered by 3/4” non-combustible A/C plywood mounted 6” AFF to 8’6” AFF. (To see a sample of A/C fire rated plywood, contact Strait Lumber 11150 E. Colfax Avenue, Aurora CO 303.366.3561; description: 4x8-23/32” AC Fire Retard Ply PLY34ACNC). The A-side (smooth side) of the sheet shall be outward facing. The A/C plywood shall be securely fastened to the wall.

11. ER location should not be adjacent to any source of EMI. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Sources of EMI should be kept 3 meters from the ER. Bandwidth for telecommunications is currently 350 MHz.

12. ER doors shall be a minimum of 36” wide by 80” high. Due to the nature of the equipment located in the ER, ERs require at least one oversized door (72” by 90”) to allow large equipment to be moved in or out. Doors should open outward if permitted by building code or be removable. ER doors shall be secured with either electronic access or a lockset specified by the University Facilities.

13. ER ceilings shall be a minimum of 8’ 6” high, unobstructed; to provide space over the equipment frames for suspended cable trays or racks. ERs shall be free of false or suspended ceilings. Ceiling protrusions (i.e. fire suppression) must be placed to assure a minimum of 8 feet of clearance from the finished floor.

14. ERs require lighting with a uniform intensity of 500 lux (50 foot candles) when measured 1 meter above the finished floor. Indirect lighting is not recommended. Connect lighting fixtures for ERs to separate electrical circuits from those that accommodate the equipment in the room. To avoid blocking or filtering the light, do not place lighting equipment above equipment cabinets, termination frames, or other freestanding equipment. Use a light colored finish to enhance room lighting. Provide emergency lighting in ERs.

15. Specific circuits for equipment in ERs will be designated during the space planning process and shall be placed according to IT Services approved blueprints. In addition to those circuits, additional electrical outlets are required in all ERs. All such electrical outlets shall be grounded, non-switched, and separately fused. ERs require one 120-VAC, 20-amp duplex receptacle per every 6 linear feet of wall space. Emergency generator power is required for ERs.
16. ERs typically house the building’s TMGB, which is connected to the building’s electrical entrance facility by the bonding conductor for telecommunications. An ER shall be equipped with a copper TMGB that is a minimum of 24” long, 4” wide, and ¼” thick. The TMGB shall be bonded to building structural steel, the entrance facility, and electrical service grounds with a minimum 6 AWG stranded copper. The TMGB shall be drilled and tapped to accept standard NEMA compliant grounding hardware. Equipment grounds shall use a minimum 6 AWG stranded, insulated copper to the TMGB and be attached with standard NEMA compliant grounding hardware. All TGBs will be bonded to the TMGB with TBBs that are a minimum 6 AWG insulated, stranded copper; with consideration given to using a 3/0 AWG conductor. Refer to J-STD-607-A and NEC Article 250.

17. Temperature and moisture shall be controlled in all ERs. Typical equipment requirements are:
   a. Temperature range from 64° F to 75° F (18° C to 24° C);
   b. Relative humidity range from 30% to 55%; humidifiers are required in ERs;
   c. Heat dissipation of 5,000 BTUs per hour per cabinet.
      1) Temperature sensors shall be configured for alarm reporting and HVAC support units shall be installed on emergency power. Consult IT Services for ER cooling requirements.

18. When cable services for any ER exceeds 1800 pairs, provide a separate room (cable vault) for cable splices. This room should be sized according to the requirements of the facility and should be located adjacent to the ER with free pathways to terminating equipment and cross-connect fields.

19. FM-200 fire suppression agent, or equivalent, is the preferred fire suppression agent in ERs. The ER should be free of automatic fire sprinklers, unless specifically required by building code. In such instances, the sprinklers should be a preaction system, not a wet pipe or dry pipe system. Additionally, such sprinkler systems must have troughs to prevent accidental water damage to the equipment.

20. Fire stops (area around sleeves, drilled core floor openings, and cables) shall be sealed or plugged with an 8-to-1 ratio expandable urethane foam with a 1” thick topping of water plug cement or equivalent. All unused sleeves must be plugged and capped with approved firestop.

END OF SECTION 27 00 00
SECTION 27 05 00 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. The term “provide” used throughout this specification and drawings shall mean “furnish, install, test, and certify”.

B. Coordinate project schedule, installation schedule, phasing and any other requirements deemed necessary with Construction Manager and/or General Contractor and all necessary trades to ensure successful completion of work.

C. Phasing, temporary distribution/equipment, cut-over and implementation shall be coordinated with the university and the Office of Information Technology (OIT), Construction Manager and/or General Contractor, Architect, and Engineer.

D. Extent of communications raceway infrastructure work is indicated by Division 27 specifications and Technology drawings and schedules and is hereby defined to include, but not by way of limitation, the provisions of:

1. Raceway systems including but not limited to conduits, cable trays, sleeves, surface raceways, telecommunication services entrance, manholes, pull-boxes, junction boxes, back-boxes, etc. as required and specified in Division 27 sections and select Division 26 sections. The Construction Manager and/or General Contractor shall coordinate this with the Sub-Contractor performing work and determine how scope of work is assigned. The purpose of this specification is to establish design intent and general system scope.

2. All communications raceway infrastructure (i.e. pathways and spaces) shall be provided as part of the Base Building Project including.

3. Communication room hardware and component fit-out including cable tray, backboard, and raceways.

4. Grounding and bonding of all metallic hardware components to the nearest telecommunications grounding bus (TGB) bar including but not limited to equipment racks, cabinets, cable trays, ladder rack, conduits, sleeves, metallic ductwork, and frames.

5. Fire stopping as required. Contractor shall provide fire stopping for all low-voltage openings (including empty low voltage raceway) once cable installation is complete. Confirm specific fire stopping scope requirements with General Contractor and/or Construction Manager.

6. Testing of the grounding systems as noted by specification, drawings, and applicable industry standards. Submit written testing results to OIT.

7. Labeling of all communication infrastructure components with mechanically printed labels.

8. Preparation and submission of product data, shop drawings, testing reports, as-built drawings, and cabling documentation as required in this specification.


10. Manufacturer components, channel and solutions warranties.

11. Installation and testing of all system and components.

12. Onsite administrative and user training.

13. Manufacturer training of components.
1.3 SUBMITTALS

A. General Description and Requirements
   1. In addition to the requirements noted herein, refer to Division 1 Specification for additional requirements. As a minimum, Contractor shall ensure all requirements listed here are met.
   2. Within 45 days after award of contract or as dictated by the construction schedule (whichever period of time is shorter), the Contractor shall submit prefabrication submittals consisting of product data and shop drawings for approval. Partial submittals will not be accepted without prior written approval from the Architect.
   3. Review of the Prefabrication Submittals by the Architect is for purposes of tracking the work and contract administration and does not relieve the Contractor of responsibility for any deviation from the Contract Documents, or from providing equipment and/or services required by the Contract Documents which were omitted from the prefabrication submittals.
   4. No portion of the project shall commence nor shall any equipment be procured until the prefabrication submittals have been approved in writing by the Architect. All installations shall be in accordance with the Contract Documents.
   5. A detailed completion schedule shall be submitted with the prefabrication submittals.
   6. Prefabrication submittals shall be accompanied by a letter of transmittal identifying the name of the project, Contractor's name, date submitted for review, and a list of items transmitted.

B. Product Data:
   1. Compliance Matrix: Provide full specification compliance matrix as described in the Specification Response section of this specification section.
   2. Warranty Information: Provide all warranty information as described in this specification section for review and approval.
   3. Component List: Provide complete submittal component list at the beginning of the submittal package. Component list shall identify each component name, manufacturer, and specific product/part number. All part numbers shall clearly indicate special options, color, accessories, etc. Component list and manufacturer cut-sheets shall be compiled to match the order of each Appendix.
   4. Cut-Sheets: Submit manufacturer’s cut-sheets on all components listed within this specification and corresponding appendix. All components and parts being used shall be highlighted in color on cut-sheets to distinguish specific product/part numbers, options, colors, accessories, etc.
   5. Product Substitutions: This specification is intended to be performance based, thus all products listed in Appendix 1: Equipment Schedule are benchmark products. The Contractor shall include the listed benchmark product lines in the initial bid as the “base” solution, unless noted otherwise. The Contractor may submit (as a proposed “alternate” solution) substitute manufacturers and models that may be more cost effective or readily available. All substitutions shall meet or exceed the minimum functional, physical, and technical specifications. Acceptance of such substitutions is at the discretion of the university, Architect, and Engineer. Additionally, the requirements of Division 1 Specifications shall apply and may supersede requirements noted herein.

C. Prefabrication Shop Drawings:
   1. Symbol Legend, Abbreviations, and Description: Provide drawings including descriptions of all abbreviations, symbols, typical mounting heights, project information, etc.
   2. One-Line Wiring Diagrams: Include one-line wiring diagrams indicating all backbone and horizontal cabling, copper pair and fiber strand counts, cable quantities, splice enclosures, etc.
   3. Site Plan: Provide complete site and exterior plans indicating all site and building façade mounted communication device outlets, equipment, and components proposed to be installed. Additionally, manholes, pull-boxes, and all major raceway routing shall be indicated for conduits 2-inches and larger. Shop drawings shall represent final conduit routing and manhole and/or pull-box placement as coordinated and/or confirmed with Service Provider, Civil Engineer and other trades.
   4. Floor Plans: Indicating all communication device outlets, equipment, and components proposed to be installed. Floor plans shall indicate cable routing origin and labeling scheme for each cable and termination position. Additionally, major raceway routing shall be indicated for cable trays and conduits 2-inches and larger, based on final coordination with all other trades. Shop drawings
shall clearly indicate areas with cable tray clearance limitations and/or other cable access limitations for review and approval by the university, Architect, and Engineer.

5. Enlarged Plans: Provide ¼” = 1’-0” enlarged plans of all communication rooms including Telecommunications Entrance Facilities (TEF), Telecommunications Rooms (TR), and Equipment Rooms (ER), indicating the position of equipment cabinets, racks, wiring terminals, patch panels, grounding equipment, cable tray, fiber and copper terminations, and other low voltage systems equipment layout within the rooms. Additionally, shop drawings shall clearly indicate final conduit/riser (core drill and/or block-out) locations and sizes as coordinated and/or confirmed with Structural Engineer and any field conditions that impact proposed location. Shop drawings shall clearly indicate areas where equipment clearances may be limited, for review and approval by the university, Architect, and Engineer.

6. Details: Including method of attachment of racks to the floor and ladder tray systems, method of attachment of wall mounted distribution frames, grounding details indicating grounding method for cabinets, racks, cable tray, cable management, and power details for rack mounted power distribution.

7. Elevations:
   a. Rack elevations indicating patch panels, fiber terminals and enclosures, vertical and horizontal cable managers, rack mounted power strips or distribution units, etc.
   b. Wall elevations of distribution frame with block size, cable routing, cable management, pair counts, method of attachment, etc.

8. Drawing Scale: Shop drawings shall be drawn to scale and completely dimensioned as to clearly show construction detail.

9. Labeling: Provide documentation of all labeling schemes for conduit, back-boxes, cables, outlets, wiring blocks and/or patch panels, device faceplates, etc.

10. Documentation: Provide a minimum of (1) hardcopy set of prints (in addition to electronic copies) for review or as indicated in Division-1 general conditions.

1.4 QUALITY ASSURANCE

A. Codes and Standards: All materials and installations shall comply with current applicable codes and standards, including but not limited to:
   2. ANSI/EIA/TIA-568-C.0: Generic Communications Cabling for Customer Premises.
   11. ASTM: American Society for Testing and Materials
   18. ICEA: Insulated Cable Engineers Association
   19. IEEE-802.11 a, g, n, a/c: Wireless Local Area Networks

COMMON WORK RESULTS FOR
COMMUNICATIONS

27 05 00 - 3
COMMON WORK RESULTS FOR
COMMUNICATIONS

20. IEEE-802.3: 10 Mb/s, 100 Mb/s, 1 Gb/s, and 10 Gb/s Ethernet Standards as applicable based on media types (twisted pair copper, fiber optics, etc.)
21. IEEE-802.3ak: 10 Gb/s Ethernet (evolving copper standard).
22. IEEE-802.3af: Power-over-Ethernet (PoE).
24. IEEE-141: Recommended Practice
27. NESC: National Electrical Safety Code
28. NEMA Stds Pub No. VE 1, Cable Tray Systems. Additionally, comply with current edition of NEC, as applicable to construction and installation of cable tray systems.
29. NEMA Std 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
32. UL Compliance: Provide products which are UL-listed and labeled.

B. Manufacturer and Product Qualifications
1. Provide products from manufacturers regularly engaged in the production of communications infrastructure components, including but not limited to, raceway, horizontal copper cabling, copper and fiber optic backbone cabling, and connecting hardware.
2. Provide products from manufacturers whose products of similar types, capacities, and characteristics have been in satisfactory use in similar type projects for not less than five years.

C. Contractor Qualifications:
1. Firms with at least seven (7) years of successful installation experience with projects utilizing communications, raceway and/or equipment similar to that required for this project.
2. The company shall have a fully staffed office with technical installations support personnel within the metropolitan area. (Exceptions to this shall be confirmed through approval by the university, Architect, and Engineer.)
3. The Low Voltage Raceway Contractor shall be a certified installer (current and in good standing with proven history) of the selected manufacturer’s raceway systems and shall provide a 25-year warranty on installation and applications.

D. All materials shall be Underwriters Laboratories (UL) or Intertek Testing Services (ETL) Listed unless otherwise indicated.

E. Coordinate with electrical work and other trades to properly interface installation of communications raceway.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment and components in factory-fabricated containers or wrappings, which properly protect equipment from damage.

B. Store equipment and components in original packaging. Store inside in a well-ventilated space protected from weather, moisture, soiling, humidity, and extreme temperatures.

C. Handle equipment and components carefully to prevent damage. Do not install damaged units or components; replace with new.
1.6 SEQUENCING AND SCHEDULING

A. All work shall be reviewed and coordinated with the Construction Manager and/or General Contractor prior to commencing.

B. Communication systems, infrastructure, raceway and equipment are sensitive to environmental conditions including but not limited to temperature, dirt, dust, and water. The contractor shall ensure the storage and installation of all communication components are sequenced and scheduled accordingly to prevent any damage, loss of performance, and warranty void of such systems. All mis-installed components shall be replaced with new parts and re-installed at the Contractor’s expense.

C. Coordinate installation with Structural, Electrical, HVAC, Plumbing, Fire Protection, and other trades to eliminate disruption and/or conflict with other systems.

D. Sequence installation of communications systems and infrastructure with other work to minimize possibility of damage and soiling during remainder of construction.

1.7 PROJECT SITE CONDITIONS

A. Prior to submitting a proposal, the Contractor shall inspect the Contract Documents, and shall become fully informed as to laws, ordinances, and regulations affecting the project. The Contractor shall immediately bring to the university, Architect, and Engineer’s attention, in writing, any existing condition or statute that contradicts, is in conflict with, or negates the Contract Documents. Failure of the Contractor to become fully informed as to all above mentioned items shall in no way relieve the Contractor from any obligations with respect to their proposal.

B. The Technology Drawings depict equipment locations, backboxes, conduit runs, cabling, etc. in a schematic manner. Field conditions and coordination with related trades may warrant relocations of field devices. No additional compensation will be allowed due to these revisions.

1.8 WARRANTY

A. A one (1) year warranty on the work shall be provided by the Contractor. If, within one (1) year after the date of final acceptance of the installation or within such longer period of time as may be prescribed by law or by the terms of any applicable special warranty required by the Contract Documents or provided by a manufacturer, any of the work or equipment is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly including all parts and labor after receipt of notice from the university to do so unless the university has previously given the Contractor a written acceptance of such condition. This obligation shall survive termination of the contract. The university shall give such notice promptly after discovery of the condition. Such notice shall be provided by the university representatives, to be identified, either verbally or in writing.

B. Nothing contained in the Contract Documents shall be construed to establish a shorter period of limitation with respect to any other obligation which the Contractor might have under the Contract Documents or any manufacturer's warranty. The establishment of the time period noted above, after the date of final acceptance or such longer period of time as may be prescribed by law or by the terms of any warranty required by the Contract Documents, relates only to the specific obligation of the Contractor to correct the work or equipment, and has no relationship to the time within which his obligation to comply with the Contract Documents may be sought to be enforced, nor to the time within which proceedings may be commenced to establish the Contractor's liability with respect to his obligations other than specifically to correct the work or equipment.

C. The university reserves the right to expand or add to the system during the warranty period using firm(s) other than the Contractor for such expansion without affecting the Contractor's responsibilities, provided
that the expansion is done by a firm which is an authorized dealer or agent for the equipment of system being expanded.

1.9 SPECIFICATION RESPONSE

A. Pricing
   1. Instructions to Bidders
      a. The following is a partial list of instructions. Bidders are responsible to provide a complete proposal inclusive of all information requested in the Contract Documents.
      b. Do not assume anything. Clarify your position in writing with your bid concerning any areas that may not be clear to you.
      c. Copies of the bid proposal shall be submitted to the university, Architect, and Engineer for review and approval.
      d. Bidders shall prepare equipment lists showing each item included in the bid. Equipment Lists must include the quantity, model number, manufacturer and price of each item listed under the generic description.
      e. Provide a detailed description of any and all voluntary alternates and include cost changes in the Voluntary Alternate Bid forms. Bidders should submit voluntary alternates that will either provide for a better system or reduce costs without degrading the system. This includes alternate manufacturer and product substitution.
      f. In the instance where the Drawings and the Specifications do not directly coincide, or coincide individually, the item of better quality, greater quantity and/or higher cost shall be included in the base bid.

B. Compliance
   1. Bidders shall submit a Statement of Qualifications with their bid proposal that shall include the following information:
      a. Company name, address, telephone number and contact person.
      b. Brief company history.
      c. Resumes of key personnel.
      d. Local staffing description (job descriptions and numbers of persons in each position).
      e. Local service capabilities (hours of operation and parts availability).
      f. Technician factory certifications.
      g. Description of local engineering and project management capabilities.
      h. Line sheet listing major suppliers of security equipment.
      i. Annual dollar value of sales, installation and service of each product line carried.
      j. List of references describing three (3) completed projects of similar size and complexity, including names and telephone numbers of the contact persons.
      k. List of references describing similar projects completed in the area including names and telephone number of the customer's contact person.
      l. List of similar projects currently under construction in the area including names and telephone numbers of the customer's contact person.
      m. Licensing information.
   2. Provide a specification compliance matrix indicating compliance or deviation for each item in the specification. The matrix shall be comprised of a list of all numbered paragraphs that appear in this Specification. Indicate compliance of the proposed equipment and/or services by the word "Comply" following each paragraph number. Indicate an exception to the requirement by the word "Exception" following the applicable paragraph number. Should the proposed equipment and/or services not entirely comply with the requirements specified, but ultimately achieve the intent, the Bidder shall explain fully the extent, or lack thereof, of compliance for the applicable equipment and/or services proposed. Instances where there is no indication of compliance or exception shall be considered non-compliant. This matrix is critical for proposal evaluation. Failure to submit may result in the disqualification of the bid. Contractor shall submit Compliance Matrix with the Bid Proposal AND at the time of Product Data submittal (as indicated previously in this specification) so that a complete security system submittal reviewed can be performed.
3. Additionally, as described in this Specification, bidders shall submit the following information with their bid proposal:
   a. Manufacturer's literature sheets for all standard manufactured items included in the equipment list and as proposed in the Voluntary Alternate Bid form, if applicable.
   b. Workload and capability statements. The statements shall detail projects that will be active during the completion of this project, and the manpower that would be available for this project.
   c. Confidentiality and return statements. The statements shall guarantee that the Contract Documents shall not be copied or distributed physically or verbally. The Contractor shall also assure the university that the Contract Documents shall be returned in their entirety upon request. The successful Contractor will be provided with as many copies as requested.
   d. Copy of manufacturer’s certification certificate.
4. Certain paragraphs of the Specification require the Bidder to provide information (possibly not listed above) in the proposal to demonstrate compliance with a requirement. If the Bidder fails to provide detailed responses to these items, the proposal will be deemed to be non-compliant to the paragraphs stated.
5. Number all pages of the bid submittal.

PART 2 - PRODUCTS

2.1 Refer to the following specification sections for additional requirements:
   A. 26 05 26 – Telecommunications Grounding and Bonding
   B. 27 05 28 – Pathways for Communication Systems

PART 3 - EXECUTION

3.1 GENERAL COMMUNICATIONS RACEWAY

   A. Examine areas and conditions under which communications raceway systems are to be installed. Notify the university, Architect, and Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.
   B. The Contractor shall be knowledgeable of work to be performed by other trades and take necessary steps to integrate and coordinate their work with other trades.
   C. The Contractor shall be responsible for furnishing all materials indicated on the drawings or as specified herein for a complete communications raceway system.
   D. All communications raceway infrastructure shall be installed in an aesthetically pleasing fashion. All surface raceway in new buildings must be approved by the university, Architect, and/or Engineer.
   E. All communications raceway infrastructure shall be installed to allow for easy adds, moves, and other changes in the future.
   F. Construction within communication rooms must be substantially complete before the installation of telecommunications cabling. This includes, but is not limited to, the installation of plywood backboard, cable tray or ladder rack, electrical outlets, light fixtures, sprinklers and ductwork.
   G. Floor to floor distribution shall be provided with concrete floor sleeves or conduits as noted on the drawings, and as required by the Architectural Design.
H. Provide protective cable bushings on all conduits immediately after installation.

I. Use only electrical 45º or 90º conduit elbows with long bend radii as follows:
   1. 6:1 bend radius of the inside conduit diameter for sizes 2” or less.
   2. 10:1 bend radius of the inside conduit diameter for sizes greater than 2”.

J. Do not place more than two 90º sweeps or exceed 100 ft. between pull boxes without providing a pull box.

K. Fire seal all raceway penetrations and openings to maintain fire rating after communications cables are installed.

3.2 LABELING

A. All communications components shall be clearly labeled using labeling devices (i.e. hand written labels are not acceptable) with white label and black text. All labels shall be consistent font type and size (for respective components).

B. The final labeling scheme shall be coordinated with the university, Architect, and Engineer prior to finalizing and initiating any work. A sample scheme shall be submitted for approval.

END OF SECTION 27 05 00
SECTION 27 05 26 - GROUNDING AND BONDING FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. System Performance Requirements.
1. The Telecommunications Entrance Facility (TEF), Telecommunications Room (TR), and Equipment Rooms (ER) require grounding and bonding. The Office of Information Technology (OIT) does not require an isolated grounding system for its voice and data networks. Each building shall have one Telecommunications Main Grounding Busbar (TMGB), which is bonded to the building’s electrical service entrance and is electrically contiguous to the Grounding Electrode Conductor (GEC). The TGMB is usually located in a TEF, ER, or in an OIT specified TR. Each TR shall have at least one Telecommunications Grounding Busbar (TGB), which is connected back to the TMGB via the Telecommunications Bonding Backbone (TBB).

1.3 SUBMITTALS

A. General Description and Requirements.
1. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

B. Product Data: (Need to create Appendix with part numbers for Grounding Spec.)
1. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

C. Prefabrication Shop Drawings:
1. One-Line Wiring Diagrams: Include one-line wiring diagrams for telecommunications grounding and bonding work which indicate layout of ground rods, location of system grounding electrode connections, routing of grounding electrode conductors, and circuits and equipment grounding connections. Additionally submit ground riser diagram for entire project. Show bus bars with transformer ground electrode conductors, etc.
2. Details: Indicating grounding method for cable tray and cabinets and/or racks.
3. Labeling: Provide documentation of all labeling schemes for grounding busbars and grounding conductors.
4. Documentation: Provide a minimum of (1) hardcopy set of prints (in addition to electronic copies) for review or as indicated in Division-1 general conditions.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.
B. Installer’s Qualifications: Firms with at least 5 years of successful installation experience on projects with telecommunications grounding work similar to that required for project.

C. Codes and Standards:
1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and the current edition of the NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits, and equipment.
2. UL Compliance: Comply with applicable requirements of UL Standards No.’s 467, Electrical Grounding and Bonding Equipment”, and 869 “Electrical Service Equipment”, pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Std 486A, “Wire Connectors and soldering Lugs for Use with Copper Conductors.” Provide grounding and bonding products which are UL-listed and labeled for their intended usage.
3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141 and 142 pertaining to grounding and bonding of systems, circuits and equipment.
4. ANSI/EIA/TIA Compliance: Comply with applicable requirements and recommended installation practices of the current editions of ANSI/EIA/TIA Standards 568 and 569 and J−STD−607.

1.5 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.10 DEFINITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL
A. Telecommunications Main Grounding Bus (TMGB).
1. Provide (1) 24-inch x 4-inch x ½-inch (600mm x 100mm x 6mm) tinned copper UL listed busbar with pre-drilled two-hole bonding lugs.
2. Pre-drilled holes shall be primarily for 4 AWG two-hole bonding lugs. Holes shall be a nominal diameter of 5/16-inch (8mm) with 5/8-inch (16mm) between the holes centerline.
3. TMGB shall also have a minimum of (6) pre-drilled two-hole lug points for #3/0 AWG bonding lugs. Holes shall be a nominal diameter of 7/16-inch (11mm) with 1-inch (25mm) between the holes centerline.

4. TMGB shall have isolated stand-offs to provide a minimum 1-inch clearance off of wall.

B. Telecommunications Grounding Bus (TGB).
1. Provide (1) 24-inch x 4-inch x ¼-inch (600mm x 100mm x 6mm) tinned copper UL listed busbar with pre-drilled two-hole bonding lugs.
2. Pre-drilled holes shall be primarily for 4 AWG two-hole bonding lugs. Holes shall be a nominal diameter of 5/16-inch (8mm) with 5/8-inch (16mm) between the holes centerline.
3. TGB shall also have a minimum of (6) pre-drilled two-hole lug points for #3/0 AWG bonding lugs. Holes shall be a nominal diameter of 7/16-inch (11mm) with 1-inch (25mm) between the holes centerline.
4. TGB shall have isolated stand-offs to provide a minimum 1-inch clearance off of wall.

C. Conductors.
1. The minimum TBB conductor size is 6 AWG, but consideration shall be given to using 3/0 AWG conductor, as per the J-STD-607-B TBB sizing table shown below.

<table>
<thead>
<tr>
<th>Grounding Conductor Size (AWG)</th>
<th>dc Resistance Per 100 ft (Copper Conductor)</th>
<th>Short-Time Rating (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>0.077800</td>
<td>391</td>
</tr>
<tr>
<td>6</td>
<td>0.049100</td>
<td>621</td>
</tr>
<tr>
<td>4</td>
<td>0.030800</td>
<td>988</td>
</tr>
<tr>
<td>3</td>
<td>0.024500</td>
<td>1245</td>
</tr>
<tr>
<td>2</td>
<td>0.019400</td>
<td>1571</td>
</tr>
<tr>
<td>1</td>
<td>0.015400</td>
<td>1981</td>
</tr>
<tr>
<td>1/0</td>
<td>0.012200</td>
<td>2499</td>
</tr>
<tr>
<td>2/0</td>
<td>0.009670</td>
<td>3150</td>
</tr>
<tr>
<td>3/0</td>
<td>0.007660</td>
<td>3972</td>
</tr>
<tr>
<td>4/0</td>
<td>0.006080</td>
<td>5008</td>
</tr>
<tr>
<td>kcmil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>0.005150</td>
<td>5917</td>
</tr>
<tr>
<td>300</td>
<td>0.004290</td>
<td>7101</td>
</tr>
<tr>
<td>350</td>
<td>0.003670</td>
<td>8284</td>
</tr>
<tr>
<td>400</td>
<td>0.003210</td>
<td>9467</td>
</tr>
<tr>
<td>500</td>
<td>0.002580</td>
<td>11834</td>
</tr>
</tbody>
</table>

AWG = American wire gauge  
dc = Direct Current  
kcmil = Thousand circular mils

a. Determine the size of the building’s AC grounding electrode conductor (GEC) for the electrical service. If the size is unknown or indeterminable, assume a 3/0 AWG GEC.
b. Determine the length of the TBB.

c. Divide 40V by the Short-Time Ampere Rating of the GEC. The result is the maximum resistance value for any TBB length.

d. Normalize the results to 100' by dividing the maximum resistance value by 0.5 for 50', 1 for 100', 2 for 200' 3 for 300’, etc. Use this calculated resistance value in the next step.

e. Refer to the table above and compare the calculated resistance value with the DC resistance values per 100’. Select the DC resistance value that does not exceed the calculated resistance value created above. The associated conductor size is the calculated TBB size.

f. The table below may be used as a planning guide for estimating the TBB size prior to using the calculated method above.

<table>
<thead>
<tr>
<th>TBB Linear Length (Feet)</th>
<th>TBB Size (AWG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 13</td>
<td>6</td>
</tr>
<tr>
<td>14 to 20</td>
<td>4</td>
</tr>
<tr>
<td>21 to 26</td>
<td>3</td>
</tr>
<tr>
<td>27 to 33</td>
<td>2</td>
</tr>
<tr>
<td>34 to 41</td>
<td>1</td>
</tr>
<tr>
<td>42 to 52</td>
<td>1/0</td>
</tr>
<tr>
<td>53 to 66</td>
<td>2/0</td>
</tr>
<tr>
<td>Greater than 66</td>
<td>3/0</td>
</tr>
</tbody>
</table>

2. A TBB may be an insulated conductor. Each telecommunications bonding conductor (from equipment) shall be a 6 AWG insulated conductor, with distinctively green colored insulation. The TBB used to bond cable tray shall be uninsulated, 6 AWG minimum.

D. Connectors.

1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

3. Welded Connectors: Exothermic-welding kits of types recommended by Cadweld (or approved equal manufacturer) for materials being joined and installation conditions.

4. Compression Fittings: All cable splices from bonding backbone to tie cables shall use irreversible compression fittings to join cable ends.

E. Grounding Electrodes.

1. Ground Rods: Copper clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

2. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Whenever two or more vertical TBBs are used in a multistory building, the TBBs shall be bonded together with a Grounding Equalizer (GE) at the building’s top floor and at a minimum of every third floor in between.

B. The TBB, GE, TMGB, and TGB shall be marked with nonmetallic labels, as specified by OIT.
C. The TBB shall be installed in its own pathway, independent of the OIT pathways.

D. Telecommunications connections shall be at 3 Ohms or less.

E. The TBB shall be placed without splices. Joined segments of a TBB shall be connected using irreversible compression-type connectors, exothermic welding, or equivalent. All joints shall be adequately supported and protected from damage. TBBs shall be placed so they avoid bends, curves, and diverts. That is, straight and linear TBB runs are required.

---

**Diagram Description**

- **BCT** - Bonding Conductor for Telecommunications; Connects to EEF, outside IT responsibility
- **EEF** - Electrical Entrance Facility; Outside IT responsibility
- **GEC** - Grounding Electrode Conductor; Outside IT responsibility
- **GER** - Grounding Electrode Rod; Outside IT responsibility
- **TBB** - Telecommunications Bonding Backbone
  Preferred TBB conductor size is 3/0 AWG, minimum 6 AWG. The TBB may be an insulated or uninsulated conductor, see J-STD-607-A.
- **Grounding Equalizer (GE) or TBBIBC** - TBB Interconnecting Bonding Conductor
  Required in multistory buildings with multiple TRs per floor. Required on top floor and every 3rd floor.
- **TEF** - Telecommunications Entrance Facility (or Service Entrance [SE])
- **TGB** - Telecommunications Grounding Busbar
  Minimum one TGB required in each TR. Minimum 6mm thick and 50 mm wide with variable length. TGB shall be insulated from its support by a minimum of 50 mm. Connect equipment and cable tray via an insulated 6 AWG conductor (with green insulation) to TGB.
- **TMGB** - Telecommunications Main Grounding Busbar
  Only one TMGB per building. Minimum 6 mm thick and 100 mm wide with variable length. TMGB shall be insulated from its support by a minimum of 50 mm.
- **TR** - Telecommunications Room

---

END OF SECTION 27 05 26
SECTION 27 05 27 – COMMUNICATIONS SPACES

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. This section describes the codes, standards, specifications, recommendations, and practices required for construction at the University of Colorado Denver | Anschutz Medical Campus for the Office of Information Technology (OIT) department. Section 27 00 00 applies to all telecommunications projects at the university.

B. The project general contractor (GC) is responsible for building telecommunications pathways and spaces as per the requirements described in this document. The project GC shall provide these specific items: spaces (work areas, telecommunications rooms, telecommunications entrance faculty, and equipment rooms), pathways (riser and horizontal distribution), grounding system, and fire protection systems, as described below. The OIT department is responsible, through its contractor, for providing cabling, data networking, and voice equipment.

Planning.

1. To facilitate provisioning of telecommunications services, the architect/engineer shall provide the university OIT with floor plan drawings for new building construction and major renovation projects during design and at construction. CAD drawings of the Electrical/Communications plans shall be provided to OIT upon release of construction document through the university project manager.

2. The project’s technology consultant shall meet with the building’s projected occupants, OIT Telecommunications Network Infrastructure (TNI) team, and other interested parties to determine the telecommunications requirements of the occupants. Compliance with overall campus telecommunications plans will also be validated during these meetings. The technology consultant shall submit all findings to OIT for review and approval.

3. The preliminary plans, indicating service locations and space requirements, will be returned to project managers for inclusion in the final plans.

Consult with university OIT for the following.

1. Acceptability for specific substitutions of specified products.

2. Guidance in the application of a standard or specification in a non-listed or design situation.

3. Approval for deviation from standards and specifications or industry-standard methods and procedures if indicated by special circumstances.

E. Workmanship. All materials and equipment shall be installed in accordance with recommendations of the manufacturer as approved by the architect, to conform to initial design requirements or specification’s and contract documents.

1.3 SUBMITTALS

A. Refer to Section 27 05 00 for requirements.
1.4 QUALITY ASSURANCE

A. Applicable Codes, Standards, and Specifications: The following list of codes, standards, specifications, recommendations, and methods and procedures are applicable to the provisioning of telecommunications services for the university. The latest editions are incorporated by reference.

2. ANSI/EIA/TIA-568-C.0: Generic Communications Cabling for Customer Premises.
11. ASTM: American Society for Testing and Materials
18. ICEA: Insulated Cable Engineers Association
19. IEEE-802.11 a, b, g, n: Wireless Local Area Networks
20. IEEE-802.3: 10 Mb/s, 100 Mb/s, 1 Gb/s, and 10 Gb/s Ethernet Standards as applicable based on media types (twisted pair copper, fiber optics, etc.)
21. IEEE-802.3ak: 10 Gb/s Ethernet (evolving copper standard).
22. IEEE-802.3af: Power-over-Ethernet (PoE).
24. IEEE-141: Recommended Practice
27. NESC: National Electrical Safety Code
28. NEMA Stds Pub No. VE 1, Cable Tray Systems. Additionally, comply with current edition of NEC, as applicable to construction and installation of cable tray systems.
29. NEMA Std 250: Enclosures for Electrical Equipment (1000 Volts maximum).
32. UL Compliance: Provide products which are UL-listed and labeled.

B. Requests for variations from code shall be submitted to the university Code Official via the university project manager and must have OIT approval. The university Code Official will either disapprove or approve the request. In general, requests for code variations shall not be looked upon favorably. Variations from standards may be authorized by OIT on a case-by-case basis and must be requested in writing by the designer through the university project manager.
C. OIT owns and maintains the university’s telephone and communications distribution system. OIT will provide design parameters for the distribution systems and for systems in individual buildings. OIT shall be consulted during project design through the assigned the university project manager.

1.5 DEFINITIONS

A. Telecommunications. Any transmission, emission, or reception of signs, signals, writings, images, and sounds, or information of any nature by wire, radio, visual, or other electromagnetic systems. Includes, but is not limited to, voice communications networks, Local Area Networks (LAN), Wide Area Networks (WAN), and Local Exchange Carriers (LEC).

B. Telecommunications Room (TR). A floor serving facility for housing telecommunications equipment, cable terminations, cross-connections, and network electronics. The TR is the recognized transition point between the building backbone and the horizontal pathway facilities.

C. Equipment Room (ER). A campus serving space. An ER houses primary system electronics, power, and media distribution for a campus or groups of buildings. ERs require extensive planning due to their size, nature, scope, and complexity. ERs are not typically required or funded for most projects. ERs may also be called server rooms, PBX rooms, disaster recovery rooms, data centers, and a variety of other terms. Contact OIT for clarification about what is placed in an ER.

D. Telecommunications Entrance Facility (TEF). Serves as the entry point into a building for the campus backbone media. TEFs interconnect the building backbone to campus backbone. The TEF is where conductive copper media receives its primary protection from sustained hazardous voltages. Therefore, significant wall space in the TEF may be required for primary protection of copper circuits. Also called the Service Entrance (SE).

E. Telecommunications Main Grounding Busbar (TMGB). The building’s main telecommunications grounding point. The TMGB is busbar placed in the TEF, ER, or a selected TR to provide interconnection to the building’s power ground via a bonding conductor for telecommunications.

F. Telecommunications Grounding Busbar (TGB). A common point of connection for telecommunications systems and equipment for bonding to ground. TGBs are required in all TRs and ERs.

G. Telecommunications Bonding Backbone (TBB). A conductor that electrically interconnects the TMGB to all TGBs.

H. Grounding Equalizer (GE). A conductor used to interconnect two or more vertical TBBS in multistory buildings. Previously called a Telecommunications Bonding Backbone Interconnecting Bonding Conductor (TBBIBC).

I. Network. Backbone media and electronics for transport of electronic information between campus entities.

J. Horizontal Distribution. The facility used for installation of media from the TR to the work area. Usually consists of cable tray and J-hooks to the work area faceplate.

K. Work Area (WA). A building space where the occupant generally interacts with the telecommunications equipment. WAs are typically defined as 100 ft² of usable space.

L. Building backbone. The pathways between floors for distribution of media. Building backbone was previously called riser cabling.
M. Campus backbone. The pathways and media that provide connectivity between the campus core and other buildings on campus. The campus backbone provides connectivity between buildings. The campus backbone represents the outside plant (OSP) infrastructure.

N. Office of Information Technology (OIT). University department responsible for telecommunications on the University of Colorado Denver | Anschutz Medical Campus.

O. Technology Consultant. A firm or member of a firm that has considerable technology design experience and possesses working knowledge and subject matter expertise in telecommunications code (NEC and NESC), industry standards (see TIA/EIA commercial standards in references), and BICSI methods and procedures (Telecommunications Distribution Methods Manual, LAN Design Manual, and Customer-Owned Outside Plant Design Manual).
1. OIT maintains a list of pre-screened technology consultants that can be obtained from the university project manager via OIT.
2. Technology consultants used for university projects shall be selected from the pre-screened technology consultant list.
3. Technology consultants not listed on the pre-screened technology consultant list must meet with OIT for certification and possible inclusion on the list. Firms vying for campus technology consultant designation must possess a registered communication distribution designer (RCDD) on staff. The RCDD must be thoroughly familiar with campus standards and methods and procedures and be dedicated to the assigned project. Contact the OIT Director of Telecommunications Networking Infrastructure (303.724.0423) for possible interview times.

PART 2 - DESIGN REQUIREMENTS FOR COMMUNICATIONS SPACES

2.1 SPECIFIC DESIGN SPECIFICATION AND CONSTRUCTION REQUIREMENTS

A. Work Area (WA).
1. A WA is defined as a building space where occupants interact with telecommunications services such as voice, data, and video. A WA may be an office, conference room, training room, demonstration room, laboratory, copy/mail room, classroom, auditorium, loading dock, areas specified by the architect or university project manager, and other areas requiring access to telecommunications.
2. Each office WA typically requires two (2) telecommunications faceplates. As a minimum, each faceplate supports an A−jack and a B−jack. Typically, telephone service is provided by the A−jack and data networking connectivity is provided from the B−jack. However, the jacks are interchangeable and can be used by either application. This enhances the infrastructure’s flexibility. One-inch conduit is used to provide a pathway inside the wall to each faceplate. The conduit is stubbed out to the top of the wall and is physically oriented towards the floor’s cable tray. Connection to the cable tray is typically by a J-hook pathway.
3. All horizontal, low-voltage cables run back to the floor serving TR as part of the university’s structured cabling standard.
   a. Horizontal cable shall be Commscope Category 6 or Category 6A (Augmented Category 6), as specified by OIT:
      1) Maximum length of horizontal cable – 90 meters or 295 feet.
         a) Allow 40 feet for access to and from the overhead cable tray and slack in the TR, yielding a maximum horizontal run length of 255 feet.
      2) Maximum length of WA station cables – 5 meters or 16 feet.
      3) Maximum length of TR patch cords – 5 meters or 16 feet.
4. The IT RCDD consultant shall identify and document the end user’s WA connectivity requirements. This includes A/B jack faceplate locales and numbers, data network requirements, voice requirements, and wireless needs. These requirements shall be delivered to OIT so a budget can be created to provide the requisite systems.
5. The IT consultant shall identify and document the placement of Emergency Services Phones (ESP) or red phones. These phones are typically placed near elevator banks or restrooms. The design goal is to place at least one ESP per floor.
   a. All ESP and wall phone installations shall comply with the following ADA side reach requirements: 1) maximum side reach height shall be 54”, 2) minimum side reach height shall be 9”, 3) maximum side reach height over an obstruction that is 24” wide and 34” high shall be 46”.
   b. All ESP and wall phone installation shall comply with the following ADA front reach requirements: 1) maximum forward reach height shall be 48”, 2) minimum forward reach height shall be 15”, 3) maximum front reach height over an obstruction shall be 44”.
   c. The ESP solution consists of three parts: red analog phone, A/B cable run, and approved signage. OIT provides this solution under a separate budget.

B. Telecommunications Entrance Facility (TEF) or Service Entrance (SE).
   1. All buildings require a TEF. The TEF serves as the entry point into a building for the campus backbone media. TEFs interconnect the building backbone to the campus backbone. The TEF shall be solely dedicated to telecommunications services. Space shall not be shared with electrical installations other than those designed and intended for telecommunications. The TEF shall be vertically aligned or stacked with the TRs to facilitate interconnection with the floors above and below. The university OIT must be consulted if the TEF does not align with the building’s TRs.
   2. TEFs may be co-located inside TRs or ERs, depending on the size of the building they support. Buildings larger than 100,000 ft2 may require a dedicated TEF. Buildings with 5 or more stories shall have a shared TR/TEF that is 10’ x 16’. These larger TEFs shall support 5 equipment racks, with one rack being dedicated to fiber optics cable management.
   3. TEF ceiling height shall be a minimum of 8’ 6”.
   4. The TEF shall be dry and free from the danger of flooding. The TEF shall not be located where water ingress is possible or probable. No water or drain piping shall be routed through the TEF that is not associated with TEF equipment. Steam, heat, and any other source of environmental hazard shall be avoided.
   5. Accessibility for the delivery of equipment as well as expansion should be provided for. TR location must also be designed for maximum cable lengths as specified in associated documents listed in References.
   6. The TEF location should not be adjacent to any source of electromagnetic interference (EMI). The TEF shall be located away from sources of EMI at a distance which will reduce the interference to 3.0 V/m throughout the deployed frequency range. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Bandwidth for telecommunications is up to 1000 MHz.
   7. Typical equipment requirements have a temperature range from 64°F to 75°F (18°C to 24°C) with a desired non-condensing, relative humidity range from 30% to 55%. Humidifiers are not typically required in TEFs. Generally, 24,000 BTUs of cooling are required in the TEF. Consult OIT for specific TEF cooling requirements. HVAC systems shall be placed with a drip pan or trough if placed in the TEF. The desired HVAC placement is outside the TEF. TEF HVAC units shall be placed on emergency power.
   8. The TEF is where conductive copper media receives its primary protection from sustained hazardous currents. Therefore, significant wall space in the TEF may be required for primary protection of copper circuits. All four TEF walls shall be covered by 3/4” non-combustible A/C plywood mounted 6” above the finished floor (AFF) to 8’ 6” AFF. The A-side (smooth side) of the sheet shall be outward facing. The A/C plywood shall be securely fastened to the wall.
   9. TEF design must conform to vibration requirements specified in TIA/EIA-569, current edition.
   10. The TEF lighting shall be a minimum of 500-lux (50 foot-candles) measured 1 meter from the finished floor and shall be mounted to meet the design configurations of the room.
11. Emergency lighting is required. Lighting shall be placed to light the front and rear of the racks.
12. The TEF door shall be a minimum of 36” wide and 80” high, without doorsill, hinged to open outward, unless restricted by building code. The TEF shall have an electronic lock. All TEF doors shall egress into a common hallway or corridor to facilitate equipment placement.
13. Floors, walls, and ceiling shall be treated and sealed to eliminate dust. Wall finish shall be bright white in color to enhance room lighting. Antistatic flooring materials shall be used.
14. All TEF ceilings shall be a minimum of 8’ 6” high, unobstructed; to provide space over the equipment frames for suspended cable trays or ladder racks. Suspended cable trays and ladder racks are typically installed at 7’ AFF. TEFs shall be free of false or suspended ceilings. Ceiling protrusions (i.e. fire suppression sprinkler heads) must be placed to assure a minimum of 8 feet of clearance from the finished floor.
15. A dedicated electrical panel shall be placed in each TEF to support telecommunications equipment. The panel shall be rated at 100 Amps or higher, as specified by OIT, to facilitate future growth. The power panel shall not be shared; it is for the exclusive use of the TEF’s equipment.
16. A typical TEF layout is shown.
17. Emergency generator power is required for the TEF. Label the panel per campus standard. For TEF planning purposes, assume 60 W/ft².
18. A minimum of three (3) dedicated, unswitched 20A, 120-VAC duplex outlets, each on a separate circuit in the dedicated TEF power panel, shall be provided for equipment power at heights and locations specified by OIT during the design phase. These three dedicated circuits shall be installed from above into the equipment racks as directed by OIT. Label all outlets to the campus standard.
19. Convenience duplex outlets, on a separate dedicated unswitched circuit, should be provided at 6’ intervals around the room. Install the convenience receptacles 15” AFF or as directed by OIT. Label all outlets to the campus standard.
20. Sleeves or slots through walls and floors shall be fitted with approved re-enterable firestopping.
21. Building backbone pathways connecting the TEF to TRs will require a minimum of four Trade Size 4” sleeves/conduits for interconnection, except where cable tray exists. A
minimum of two (2) spare conduits must be installed when the TEF is not vertically aligned from floor-to-floor to allow for lower fill ratios. Sprinkler heads shall be provided with wire cages to prevent accidental discharge. Preactive sprinklers are preferred over wet pipe or dry pipe systems. If wet pipe or dry pipe systems are employed, then drainage troughs shall be provided under the sprinkler heads and pipes to prevent leakage onto the TEF equipment. High temperature heads are preferred.

C. Telecommunications Room (TR).

1. A minimum of one TR shall be designated per floor and that TR shall be solely dedicated to telecommunications services. Space shall not be shared with electrical installations other than those designed and intended for telecommunications.

2. TRs shall be vertically stacked to facilitate interconnection with the floors above and below.

3. All low voltage cables placed on a floor are homed back to the floor serving TR, as part of the structured cabling standard.

4. The TR shall be dry and free from the danger of flooding. The TR shall not be located where water ingress is possible. No water or drain piping shall be routed through the TR that is not associated with TR equipment. Steam, heat, and any other source of environmental hazard shall be avoided.

5. The minimum TR size is 10’ x 12’. Ceiling height shall be a minimum of 8’ 6’’. Variations in size shall be approved by OIT on a case-by-case basis and will be dependent upon the floor size and applications to be served.

6. TRs shall be designed to meet floor loading (minimum floor loading of 50 lb/ft²) as specified in the references section.

7. TR location should not be adjacent to any source of EMI. The TR shall be located away from sources of EMI at a distance which will reduce the interference to 3.0 V/m throughout the deployed frequency range. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Telecommunications bandwidth is up to 500 MHz.

8. TRs require a temperature range from 64°F to 75°F (18°C to 24°C). The desired non-condensing, relative humidity range is from 30% to 55%. Humidifiers are not typically required in TRs. Temperature sensors shall be configured for alarm reporting and HVAC support units shall be installed on emergency power. A minimum of one air change per hour is required. Each TR supports 4 racks of equipment, with 20,000 BTUs of cooling required. Fan coil units are the usual cooling source. HVAC systems shall be placed with a drip pan or trough if placed in the TR. The desired HVAC placement is outside the TR. TR cooling shall be placed on emergency power.

9. All four TR walls shall be covered by 3/4" non-combustible A/C plywood mounted 6” AFF to 8'6” AFF. The A-side (smooth side) of the sheet shall be outward facing. The plywood shall be securely fastened to the wall.

10. TR design must conform to vibration requirements specified in TIA/EIA–569.

11. The lighting shall be a minimum of 500-lux (50 foot-candles) measured 1 meter from the finished floor and shall be mounted to meet the design configurations of the room. Emergency lighting is required in all TRs. Lighting shall be placed to light the front and back of the racks.

12. The TR door shall be a minimum of 36” wide and 80” high, without doorsill, hinged to open outward, unless restricted by building code. The TR shall have an electronic lock.

13. Floors, walls, and ceiling shall be treated and sealed to eliminate dust. Wall finish shall be bright white in color to enhance room lighting. Antistatic flooring materials shall be used.

14. All TR ceilings shall be a minimum of 8’ 6” high, unobstructed; to provide space over the equipment frames for suspended cable trays or ladder racks. Suspended cable trays and ladder racks are typically installed at 7’ AFF in TRs. TRs shall be free of false or suspended ceilings. Ceiling protrusions (i.e. fire suppression sprinkler heads) must be placed to assure a minimum of 8 feet of clearance from the finished floor.
15. A dedicated electrical panel shall be placed in each TR to support telecommunications equipment. The panel shall be rated at 100 Amps, or higher as specified by OIT, to facilitate future growth. The panel may not be shared; it is for the exclusive use of the TR’s equipment. Emergency generator power is required for all TRs. Label the panel per campus standard. For TR planning purposes, plan on 60 W/ft².

16. A minimum of two dedicated, unswitched 20A, 120-VAC duplex outlets, each on a separate circuit in the dedicated TR power panel, shall be provided for equipment power at heights and locations specified by OIT. These two dedicated circuits shall be installed from above into the equipment racks as directed by OIT. Label all outlets to the campus standard.

17. Convenience duplex outlets, on a separate dedicated unswitched circuit, should be provided at 6’ intervals around the room. Install the convenience receptacles 15” AFF or as directed by OIT. Label all outlets to the campus standard.

18. Sleeves or slots through walls and floors shall be fitted with approved re-enterable firestopping.

19. Sample TRs shown below.

20. Building backbone pathways connecting TR’s will require a minimum of four (4) Trade Size 4” sleeves/conduits for interconnection, except where cable tray exists. A minimum of two (2) spare conduits must be installed when TR’s are not vertically aligned from floor-to-floor to allow for lower fill ratios.

21. Sprinkler heads shall be provided with wire cages to prevent accidental operation. Preaction sprinklers are preferred over wet pipe or dry pipe systems. If wet pipe or dry pipe systems are employed, then drainage troughs shall be provided under the sprinkler heads and pipes to prevent leakage onto the TR equipment. High temperature heads are preferred.

22. The TR is sized to support all low-voltage applications including: building automation systems (BAS); fire, life, and safety systems; overhead paging; electronic security systems; distributed antenna systems (DAS); and other low-voltage systems, as approved.
D. Equipment Room (ER).
1. ERs are not required or funded for most buildings; contact OIT for need, design requirements, and placement.
2. Generally, each campus requires a minimum of one ER. Buildings may require an ER to house PBXs, servers, disaster recovery rooms, and other computing hardware. The OIT department will specify when an ER is required. ERs shall be exclusively dedicated to telecommunications services or the associated tenant IT systems. ER space must not be shared with electrical services other than those designed and intended for telecommunications. The ER should be centrally located to minimize the size and length of backbone cabling as well as provide easements and pathways for backbone and carrier services required of the room. The room shall not be adjacent to any high-voltage electrical services or water mains. A location should also be selected to allow for movement of large or heavy equipment. Access to cable pathways are required. ER walls should extend to structure and provide a sealed environment for equipment.
3. Consult TIA-942, Telecommunications Infrastructure Standard for Data Centers for ER design and implementation guidance. The university desires that ERs be built within a Tier 2 (redundant components) to Tier 3 (concurrently maintainable) framework. See 27 62 01 – Data Center standard.
4. The ER may also serve as the TEF facility for local exchange carriers (LEC) or competitive local exchange carrier (CLEC) where such a separate facility does not exist. Adjacency to existing carrier entrance facilities is required.
5. Sizing of an ER will be calculated using area of service, types of service provided, and projections of growth. OIT will provide space requirements based on these factors. The minimum size of an ER for OIT is 500 ft². The size requirement may be smaller for non OIT ERs. Minimum working clearances of 3 feet shall be provided for all scheduled and installed equipment.
6. ERs may require access (raised) flooring to allow for the cable routing from cable vaults to equipment frames and PBX equipment, as specified by OIT. Cable tray, or equivalent, must be provided for cable management under the raised floor, if provided. Finished floor height must be at least 12” from the sub-floor to accommodate the cable management systems. The plenum area may be used for air handling for equipment cooling. All metal parts of the raised floor must be bonded to ground. Floor panels must be covered with high-pressure laminate or a durable, vinyl tile resistant to static electricity.
7. Floor loading capacity shall be sufficient to bear both the distributed and concentrated load of the installed equipment. The ER distributed loading shall be at least 100 lb/ft² and the concentrated loading must be at least 2000 lb. Distributed floor loading may range as high as 350 lb/ft². Contact OIT for specifics.
8. ER design must conform to vibration requirements specified in TIA/EIA–569.
9. The ER shall be dry and free from the danger of flooding. The ER must not be located where water ingress is possible or probable. No water or drain piping shall be routed through the ER that is not associated with ER equipment. Steam, heat, and any other source of environmental hazard shall be avoided.
10. Water leak detection and alarming required.
11. The floors, walls, and ceilings shall be treated and sealed to eliminate dust.
12. All four walls in the ER shall be covered by 3/4" non-combustible A/C plywood mounted 6” AFF to 8’6” AFF. The A-side (smooth side) of the sheet shall be outward facing. The A/C plywood shall be securely fastened to the wall. Wall finish shall be bright white in color to enhance room lighting.
13. ER location should not be adjacent to any source of EMI. Interference may not exceed 3.0 V/m throughout the usable bandwidth of the communications cabling. Sources of EMI should be kept 3 meters from the ER.
14. ER doors shall be a minimum of 36” wide by 80” high. Due to the nature of the equipment located in the ER, ERs may require at least one oversized door (72” by 90”) to allow large equipment to be moved in or out. Doors shall open outward. ER doors shall be secured with
electronic access locks. All ER doors shall egress into a common hallway or corridor to facilitate equipment placement.

15. ER ceilings shall be a minimum of 8’ 6” high, unobstructed; to provide space over the equipment frames for suspended cable trays or racks. ERs shall be free of false or suspended ceilings. Ceiling protrusions (i.e. fire suppression) must be placed to assure a minimum of 8 feet of clearance from the finished floor.

16. ERs require lighting with a uniform intensity of 500 lux (50 foot candles) when measured 1 meter above the finished floor. Indirect lighting is not approved for ERs. Connect lighting fixtures for ERs to separate electrical circuits from those that accommodate the equipment in the room. To avoid blocking or filtering the light, do not place lighting equipment above equipment cabinets, termination frames, or other freestanding equipment. Lighting shall be placed to light the front and rear of the racks. ERs may require emergency lighting as directed by OIT.

17. A dedicated electrical panel shall be placed in each ER to support telecommunications equipment. The panel may be rated at 200 Amps, or as specified by OIT, to facilitate future growth. The panel may not be shared; it is for the exclusive use of the ER’s equipment. Emergency generator power is required for the ER. Label the panel per campus standard. UPS are also required, sized to handle a 10-minute outage. For ER planning purposes, assume 200 W/ft².

18. Temperature and moisture shall be controlled in all ERs. Typical equipment room requirements are:
   a. Temperature range from 64°F to 75°F (18°C to 24°C).
   b. Relative humidity range from 30% to 55%; humidifiers are required in ERs.
   c. Heat dissipation of up to 30,000 BTUs per hour or higher per cabinet. Consider room cooling, row cooling, or rack cooling topologies to achieve this heat removal. Cold and hot aisles are desired, with row-based cooling vice room CRACs. Temperature sensors shall be configured for alarm reporting and ER cooling units shall be installed on emergency power. Consult OIT for ER cooling requirements.

19. When copper cable services for any ER exceeds 1800 pairs, provide a separate room (cable vault) for cable splices. This room should be sized according to the requirements of the facility and should be located adjacent to the ER with free pathways to terminating equipment and cross-connect fields.

20. The ER should support a three-phased fire detection and suppression system.
   a. An air sampling fire detection system may be required. A very early smoke detection apparatus (VESDA) that sniffs for incipient, ambient smoke particles is desired. Contact OIT for desired vendors of solutions already in use.
   b. An HFC-227ea (FE-227 or FM-200, FM-200 preferred) inert gas fire suppression agent may be required, as directed by OIT.
   c. A preaction water-based fire suppression sprinkler may be requirement. Such sprinkler systems should have rack troughs to prevent accidental water damage to the equipment. The sprinklers should be caged or recessed and have high temperature valve fuse release heads. Equipment power off should be initiated prior to water release to minimize water damage to equipment.

21. Class C (or ABC) hand-held fire extinguishers shall be placed inside the ER. Pull stations shall be placed at all doors. EPO buttons are required at each door. Label all stations to campus standards. EPO buttons and pull stations shall have safe guard features to preclude accidental release.

22. Fire stop penetrations (area around sleeves, drilled core floor openings, and cables) shall be sealed or plugged with an 8-to-1 ratio expandable urethane foam with a 1” thick topping of water plug cement or equivalent. All unused sleeves must be plugged and capped by the GC with approved firestop.

END OF SECTION 27 05 27
SECTION 27 05 28 - PATHWAYS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. Systems Performance Requirements
   1. Provide pathways for converged low voltage systems such as telephone, data networking, security access control, closed circuit TV, community antenna TV, building automation systems, overhead-paging systems, and similar systems. Coordinate all pathways with the Office of Information Technology (OIT). Systems outside this scope require separate cable trays.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Product Data for the following products:
   1. Raceways and fittings.
   2. Wireways and fittings.
   3. Boxes and fittings.

C. Installation Instructions: Manufacturer’s written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

D. Submit a combination ductwork, piping, and cable tray plan for coordination, providing section views of areas as required, in accordance with the requirements of Section 26 05 00.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer’s Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.
F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.

H. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.’s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.

I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, “Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps.”

1.5 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.10 DEFINITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Acceptable Manufactures: subject to requirements, provide products by the following:
   1. Chalfant Manufacturing Company
   2. B-Line Systems, Inc
   3. Square-D Company
   4. TJ Cope, Inc.

2.2 GENERAL MATERIALS
A. Ladder Type Cable Tray:
   1. Description: NEMA VE 1, Class 20C ladder type tray, ventilated with solid sides.
   2. Material: Aluminum that complies with the Aluminum Association’s alloy 6063-T6 for rails, rungs, and cable trays and alloy 5052-H32 or alloy 6061-T6 for fabricated parts.
   3. Protect steel hardware against corrosion by galvanization according to ASTM B 633 or cadmium plating according to ASTM B 766.
4. Finish: fabricate cable tray products with rounded edges and smooth surfaces
5. Width:
   a. 24-inch in main corridors.
   b. 18-inch feeders.
   c. Minimum width is 12-inches
7. Rung Spacing: 9-inch
8. Load: 200 pounds/foot minimum.
10. Length: 14-foot sections maximum, 12-foot sections preferred.
11. Provide manufacturer's standard components such as clamps, 90-degree bends, tees, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
12. Wire Basket shall not be used on campus.
13. Capacity of cable tray per NEC:

<table>
<thead>
<tr>
<th>Cable tray width, inches</th>
<th>Cable tray depth, inches</th>
<th>“Thick” Cat 6 cable diameter, inches</th>
<th>Cat 6 cable area, inches</th>
<th>Square inches in cable tray</th>
<th>Number of Cat 6 cables supported in cable tray</th>
<th>Number of Cat 6 cables per NEC 50%* maximum fill</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3</td>
<td>0.25</td>
<td>0.0491</td>
<td>18</td>
<td>367</td>
<td>183</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>0.25</td>
<td>0.0491</td>
<td>24</td>
<td>489</td>
<td>244</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>0.25</td>
<td>0.0491</td>
<td>36</td>
<td>733</td>
<td>367</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>0.25</td>
<td>0.0491</td>
<td>27</td>
<td>550</td>
<td>275</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>0.25</td>
<td>0.0491</td>
<td>36</td>
<td>733</td>
<td>367</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>0.25</td>
<td>0.0491</td>
<td>54</td>
<td>1100</td>
<td>550</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>0.25</td>
<td>0.0491</td>
<td>36</td>
<td>733</td>
<td>367</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>0.25</td>
<td>0.0491</td>
<td>48</td>
<td>978</td>
<td>489</td>
</tr>
<tr>
<td>12</td>
<td>6</td>
<td>0.25</td>
<td>0.0491</td>
<td>72</td>
<td>1467</td>
<td>733</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>0.25</td>
<td>0.0491</td>
<td>54</td>
<td>1100</td>
<td>550</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>0.25</td>
<td>0.0491</td>
<td>72</td>
<td>1467</td>
<td>733</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>0.25</td>
<td>0.0491</td>
<td>108</td>
<td>2200</td>
<td>1100</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>0.25</td>
<td>0.0491</td>
<td>72</td>
<td>1467</td>
<td>733</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
<td>0.25</td>
<td>0.0491</td>
<td>96</td>
<td>1956</td>
<td>978</td>
</tr>
<tr>
<td>24</td>
<td>6</td>
<td>0.25</td>
<td>0.0491</td>
<td>144</td>
<td>2934</td>
<td>1467</td>
</tr>
</tbody>
</table>

* NEC (2008) para 392.9(B).

B. Conduit:
   1. Refer to Section 26 05 33 – Raceway and Boxes for Electrical Systems, for conduit requirements.

C. Pull Boxes:
   1. Description: galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers.
   2. Refer to Part 3 – Execution for additional requirements.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Ladder Type Cable Tray
   1. Install in accordance with manufacturer's instructions.
2. Install metallic cable tray in accordance with NEMA VE 1.
3. Install cable tray in accordance with NEMA FG 1.
4. Support trays in accordance with Section 26 05 29. Provide supports at each connection point, at the end of each run, and at other points to maintain the proper loading rate. All-thread supporting cable tray shall be covered 12-inches from the base of support to prevent cable damage during installation.
5. Use expansion connectors when the cable tray run exceeds 90-feet or where required.
6. Remove burrs and sharp edges from cable tray.
7. Make cable tray connections and changes in direction and elevation using standard fittings. Cable tray shall use factory T’s, sweeps, and interconnections. The cable tray shall be continuous, without gaps, opening, or breaches.
8. Install cable tray to facilitate cable placement; access to the cable tray should not be restricted.
   a. All overhead and beneath floor infrastructure collisions should be presented in 3d CAD to the OIT PM for their review and routing approval.
   b. A minimum of 12-inches access headroom shall be provided and maintained above the cable tray.
   c. A minimum of 3-inches of clearance shall be maintained below the cable tray.
   d. Clear working space adjacent to the cable tray shall be 30-inches.
   e. Desired cable tray clearance from fluorescent light fixtures is 24-inches when parallel and 12-inches when crossing.
   f. Cable tray installation height shall not exceed 11-feet (top of tray). Contractor shall coordinate any exceptions with the University, Architect and Engineer.
   g. Coordinate resolution of obstructions with OIT.
9. Seal cable tray penetrations through fire and smoke barriers according to Section 26 05 29.
   a. Cable tray shall be unbroken and suitably firestopped with re-enterable firestopping when passing through a firewall. Trade Size 4” sleeves shall be required for connection of cable tray through walls. OIT approved mechanical firestopping may be substituted for approved nonmechanical firestopping. OIT approves all firestopping substitutions.
10. Ground and bond cable tray at each section connection as per the provisions of Section 27 05 26.
    a. Provide continuity between cable tray components.
    b. Use anti-oxidant compound to prepare aluminum contact surfaces before assembly.
    c. Provide a 6 AWG bare copper equipment grounding conductor through entire length of cable tray; bond to each component.
    d. Bonding connections to cable tray may be made using mechanical or exothermic connectors.
    e. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. Use those specified in UL 486A if manufacturer’s torque values are not indicated.
11. Warning Signs:
    a. Install warning signs on 50-foot centers along cable tray, located to be visible.
    b. Engraved Nameplates: 1/2-inch high black letters on yellow laminated plastic nameplate, engraved with the following wording: Warning! Do not use cable tray as walkway, ladder, or support. Use only as mechanical support for OIT low voltage cables, conduits, and innerducts.

B. Conduit
1. Telecommunications conduits shall maintain large bends and sweeps. Provided below are the ratios for minimum conduit bend radius to conduit size diameter.
   a. 2-inches (50mm) and smaller: 6:1
   b. Larger than 2-inches (50mm): 10:1
2. A 2” minimum reamed and bushed conduit shall be provided from the cable tray to each room. This entrance sleeve shall be shared by all low voltage systems entering the room. A larger sleeve, as specified by OIT, may be required depending upon the room’s size and low voltage requirements.
3. A 1” conduit shall be used to provide a pathway inside the wall to each work area outlet. The conduit shall be stubbed out to the top of the wall and be physically oriented towards the floor’s cable tray. The conduit end shall be reamed and bushed.

4. If due to obstructions, limited access ceilings, or in clinical areas, conduit shall be used in lieu of J-hooks. All conduit runs shall be coordinated with and approved by OIT.
   a. All overhead and beneath floor infrastructure collisions should be presented in 3d CAD to the OIT PM for their review and routing approval.
   b. No section of conduit shall be more than 100’ in length or contain more than two 90° bends between pull boxes or pull points.
   c. Boxes shall not be used in lieu of bends. Electrical 90° elbows (type LB) are not permitted. Corresponding conduit ends must be aligned within boxes.
   d. All conduit ends shall be reamed and bushed.
   e. Conduit shall comply with NEC and local codes, standards, and specifications. OIT may stipulate additional specifications as required.
   f. The bend radius for < 2” conduits should be 6 times the internal diameter of the conduit. Conduits over 2” OD shall have a bend radius at least 10 times the internal diameter of the conduit. Wide sweeps shall be used for all conduits over 2”.
   g. Polyline pull strings with a strength rating of 200 pounds shall be provided for all conduit runs.
   h. Work area outlets. A work area telecommunications outlet shall be a four-plex, deep box with a single-gang mud ring unless otherwise specified during design.
   i. Building backbone. Building backbone (riser) conduits shall be Trade Size 4” conduit, minimum. Measured pulling tape shall be provided in all horizontal or vertical building backbone conduits.

C. J-Hooks
   1. From the stubbed work area conduit, J-hooks shall be provided and installed by the cable installer to provide a pathway to the cable tray.
      a. The section of conduit minimum J-hook size is 2”.
      b. J-hooks are required every 48” to 60” along the pathway.
      c. Individual J-hooks may support no more than 50 cables.
      d. J-hooks shall not be shared with other low voltage systems. That is, all other low voltage systems require their own J-hook pathway. J-hook support rods may be shared at pathway crossings or where approved by OIT beforehand.
         a. When J-hook support rods are shared at crossings or at OIT approved locations, a minimum clearance of 12” is needed between low voltage J-hooks and telecommunications J-hooks.
         b. Telecommunications J-hooks shall be placed at the bottom of any shared support rod to facilitate frequent moves, adds, and changes.
      e. Telecommunications J-hook wire supports shall be distinguished by their blue color.
      f. J-hook wire supports shall be secured at both ends as per NEC 300.11.

D. Junction and Pull Boxes:
   1. Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers. Pull boxes installed in finished spaces must be flush mounted cabinets provided with trim, hinged door and flush latch and lock to match flush mounted panel board trim. Exact size shall meet minimum industry standards based on conduit quantities and stacking arrangement, as indicated in the table below:
2. Size: Provide pull and J-boxes for telecommunications, signal, and other systems at least 50% larger than would be required by article 370 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

3.2 TESTING, CLEANING AND CERTIFICATION

A. Test the installed cable tray by performing the following.
1. Visually inspect joints and connections for mechanical continuity.
2. Measure ground resistance of each cable tray system from the most remote element to the point where connection is made to service disconnect enclosure grounding terminal. Record results in ohms.
3. Certify and report results of inspection and electrical connectivity tests in writing to the university Program Manager and OIT department.

END OF SECTION 27 05 28
SECTION 27 05 43 – OUTSIDE PLANT FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work in this section.

1.2 SUMMARY

A. This section describes the codes, standards, specifications, recommendations, and practices required for outside plant (OSP) construction at The University of Colorado Denver | Anschutz Medical Campus for the Office of Information Technology (OIT) department. Section 27 05 43 applies to all OIT outside plant projects at all university campuses.

   1. University OSP should be designed to facilitate a 75 year lifespan.

B. The project general contractor (GC) is responsible for building OSP pathways and spaces as per the requirements described in this standard. OIT is responsible, through its contractor, for providing copper and fiber media placed in the OSP pathways and spaces.

C. Submit corrections, comments, questions, or omissions about this OSP standard to the OIT department via the university project manager.

D. Planning.

   1. To facilitate expansion of telecommunications services via OSP pathways and spaces, provide OIT with floor plan drawings for new building construction and major renovation projects during design and at construction. Provide CAD drawings of the Electrical/Communications plans to OIT upon release of construction document through the university project manager. These documents will serve as a baseline for OSP build out and expansion.

   2. The preliminary plans, indicating service locations and space requirements, will be returned to project managers for inclusion in the final plans.

E. Consult with OIT for the following.

   1. Acceptability for specific substitutions of specified products.

   2. Guidance in the application of a standard or specification in a non-listed or design situation.

   3. Approval for deviation from standards and specifications or industry-standard methods and procedures if indicated by special circumstances.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Product Data for the following products:

   1. Maintenance holes and fittings.

   2. Hand holds and fittings.

   3. Conduits and fittings.

C. Installation Instructions: Manufacturer’s written installation instructions for maintenance holes, hand holes, and underground conduits and associated products.
1.4 QUALITY ASSURANCE

A. The following list of codes, standards, specifications, recommendations, and methods and procedures are applicable to the provisioning of OSP at the university. They are incorporated by reference. The most current version is referenced.

3. TIA/EIA–606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4. J–STD–607 Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
5. TIA/EIA–758 Customer–Owned Outside Plant Telecommunications Cabling Standard

1.5 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.10 DEFINITIONS

A. Telecommunications. Any transmission, emission, or reception of signs, signals, writings, images, and sounds, or information of any nature by wire, radio, visual, or other electromagnetic systems. Includes, but is not limited to, voice communications networks, Local Area Networks (LAN), Wide Area Networks (WAN), and Local Exchange Carriers (LEC).

B. OSP Spaces. Consists of maintenance holes (MH), handholes (HH), pedestals, cabinets, and vaults. MHs are used as access points for pulling and splicing cables. HHs are smaller than MH and are used for pulling cables. HHs do not typically serve as splice points. Pedestals provide access to smaller splices, interconnects, and cables. Cabins are used as cross-connects for aerial and direct buried solutions. Vaults provide environmentally protected spaces either above grade or below grade.

C. OSP Pathways. Pathways are the conduits that interlink OSP spaces and end points such as buildings. Pathways can be underground or direct buried infrastructure. The third OSP pathway method, aerial pathways, is not used on campus.
D. Telecommunications Entrance Facility (TEF). Serves as the entry point into a building for the campus backbone media. TEFs interconnect the building backbone to campus backbone. The TEF is where conductive copper media receives its primary protection from sustained hazardous voltages. Also called the Service Entrance (SE).

E. OSP media. Copper and fiber optic media placed in the OSP pathways to link structures back to the campus core. These materials are typically placed by OIT or their approved contractor.

F. Campus backbone. The pathways and media that provides connectivity between buildings.

G. Office of Information Technology (OIT). University department responsible for telecommunications on the University of Colorado Denver | Anschutz Medical Campus (the university) campuses.

H. Outside Plant (OSP). The pathways, spaces, and media that provide telecommunications between buildings. OSP is used to support voice, data, video, electronic security, building automation systems, fire, life, and safety systems, and other low voltage systems, as they evolve.

I. OSP Consultant. A firm or member of a firm that has considerable technology and OSP design experience and possesses working knowledge and subject matter expertise in telecommunications code (NEC and NESC), industry standards (see TIA/EIA standards in references), and BICSI methods and procedures (Telecommunications Distribution Methods Manual and Customer-Owned Outside Plant Design Manual).
   1. OIT maintains a list of pre-screened technology consultants that can be obtained from the university project manager via OIT.
   2. Select technology consultants for the university projects from the pre-screened technology consultant list.
   3. Technology consultants not listed on the pre-screened technology consultant list must meet with OIT for certification and possible inclusion on the list. Firms vying for campus technology consultant designation must possess a registered communication distribution designer (RCDD) with outside plant (OSP) certification on staff. The RCDD/OSP must be thoroughly familiar with campus standards and methods and procedures and be dedicated to the assigned project. Contact the OIT Director of Operations (303.724.3443) for possible interview times.

PART 2 - GENERAL

2.1 OSP DESIGN SPECIFICATIONS AND CONSTRUCTION REQUIREMENTS

A. OSP Trunk (backbone) Spaces.
   1. Maintenance Hole (MH).
      a. General description.
         1) MHs are concrete enclosures with a removable lid that permits internal access. MHs house splice closures, racking, a grounding and bonding system, drainage, sump, cabling, and other components. MHs are used to facilitate placement of fiber and copper cables. MHs are considered confined spaces.
      b. Safety.
         1) MHs are considered confined spaces containing possible hazardous atmospheres such as flammable, explosive, asphyxiating, or toxic environments. Prior to entry, check all MHs for hazardous atmosphere conditions. Mitigate all conditions found. Ensure the MH area is free of other hazards such as engulfing, immersion, entrapment, auto emissions, etc. MHs on or near roadways require traffic control, signage, and safety cones to prevent vehicular accidents. Two-person crews are required when entering campus MHs.
      c. Joint use.
         1) Joint use of OIT MHs is prohibited. OIT MHs are not shared with other utilities except those needed to directly service OIT requirements.
      d. Material.
1) Precast concrete MHs are preferred. These ASTM standards apply ASTM C 478, ASTM C 857, ASTM C 858, ASTM C 891, and ASTM C 1037. Precast MH vendors include Amcor and Vaughn Concrete Products, among others. Place MH on a minimum 12” bed of gravel, sand, or squeegee (pea-sized gravel mixed with sand).

e. Conduit run length.
   1) The maximum conduit run length between campus MHs is 600’.

f. Physical placement.
   1) Place MHs out of roadways, if possible. MHs shall not be placed within 50’ of the curb radius of intersecting roads. The desired location for MH location is under sidewalks paralleling campus roads. MHs are placed to provide convenient telecommunications access to buildings.

g. Sizing.
   1) Campus MHs are 10’ wide x 10’ long x 7’ high.

h. Loading.
   1) H-20 loading or better desired. Minimum concrete strength is 3500 PSI. Higher loading strength may be required depending upon MH placement locale.

i. Orientation.
   1) Place MHs so their four walls are oriented north-south and east-west.

j. Windows.
   1) Place MH windows in each wall capable of supporting 16 bells. All four walls and windows may support cable placement.

k. Equipment.
   1) Equip all MHs with a cast iron 32” cover, minimum 12” sump, corrosion-resistant pulling irons with minimum 7/8” pulling eyes, grounded cable racks (if metallic), grounding and bonding system, and a fixed ladder. MH copper grounding rods shall be a minimum ½” in diameter by 8’ in length. Bond and ground all metallic parts to the grounding rod with a minimum 6-AWG green insulated conductor.

l. Water infiltration and seepage mitigation.
   1) Seal MH bells to preclude water infiltration and seepage. Sump pumps may be specified to mitigate unusual conditions. Place MH-to-building underground.
conduit runs uphill so that water infiltration and seepage flows to the MH, as shown in the sketch below. A minimum drain slope of 12.5” per 100’ is required when extending conduits away from building structures. Bow MH-to-MH conduit runs upwards to preclude MH-to-MH water infiltration and seepage, as illustrated below. A minimum drain slope of 12.5” per 100’ shall extend from the middle of the span to each MH.

**OSP water infiltration and seepage mitigation construction rules**

m. MH designator.
   1) OIT will assign campus MHs a letter and number designator.

n. Opening.
   1) Each MH shall have a single opening, given their 10’ x 10’ x 7’ dimensions.

o. Covers.
   1) MH covers shall be 32” in diameter. Covers larger than 32” may be needed on occasion. Covers larger than 32” diameter shall be approved by OIT prior to placement. If larger covers are required, they shall be 38” in diameter, if approved by OIT. The 38” cover, if approved, shall also have a reducer cover for easier access and removal.

p. Cover labeling.
   1) All campus OIT MH covers shall be permanently labeled “COMMUNICATIONS”.

q. Cover material.
   1) Cast iron covers are required.

r. Cover loading.
   1) MH covers shall be rated for the expected dynamic and static loads, typically H-20 or better.

s. Cover locks.
   1) MH covers shall include a lock, as specified by OIT. The locking cover shall use the university registered key.

t. Cover lock signage.
   1) All cover locks shall be labeled to show owner and contact number, as illustrated below.
u. Flush mounted covers.
   1) Place MH covers so they are flush with road surfaces, sidewalks, or the grade.

v. Documentation.
   1) Deliver As-builts of the MH OSP system to OIT, in the prescribed format and media.

2. Hand Hole (HH).
   a. General description.
      1) HHs facilitate placing of cables in a conduit system. HHs shall not be used in place of a MH or in the main campus conduit system. HHs support connections to the campus conduit system. HHs shall not be used for splicing cables together.
   b. Joint Use.
      1) Joint use of OIT HHs is prohibited. OIT HHs are not shared with other utilities except those needed to directly service OIT requirements.
   c. Placement.
      1) HHs are placed when the bends exceed two 90-degree bends or a total of 180-degrees. HHs are also placed when the secondary, in-tract run length exceeds 200’ to the main campus backbone conduit system or other pathway. HHs are placed out of roads and other heavy load areas.
   d. Sizing.
      1) HHs shall not exceed 4’ in length by 4’ in width by 4’ in depth.
   e. Conduits supported.
      1) HHs shall not house more than four 4” Trade Size 4 conduits, except as authorized by OIT.
   f. Covers.
      1) HH covers shall be of about the same size as the HH and rated for the expected load.
   g. Water infiltration and seepage mitigation.
      1) Seal HH conduit bells to preclude water infiltration and seepage. Place HH-to-building underground conduit runs uphill so that water infiltration and seepage flows to the HH, as shown in the sketch below. A minimum drain slope of 12.5” per 100’ is required when extending conduits away from building structures. HH-to-HH or HH-to-MH conduit runs shall be bowed upwards to preclude HH-to-HH or HH-to-MH water infiltration and seepage, as illustrated below. A minimum drain slope of 12.5” per 100’ shall extend from the middle of the span to each HH. HHs shall have provisions for drainage such as an open bottom, drain holes, sump-hole, etc. HHs shall be placed on a 12” bed of gravel, sand, or squeegee.
OUTSIDE PLANT FOR COMMUNICATIONS

---

**OSP water infiltration and seepage mitigation construction rules**

- **HH designator.**
  1. Campus HHs shall be assigned a three-letter and number designator by OIT (NAC1 for example). The HH designation letters are associated with the project the HH is supporting.

- **Documentation.**
  1. Deliver As-builts of the HH OSP system to OIT, in the prescribed format and media.

3. **Pedestals.**
   a. **General description.**
      1. Pedestals house splice closures and terminals. A BD3 primary distribution pedestal housing a 50-pair cable and a 100-pair splice is the largest pedestal permitted on campus.
   b. **Limited use.**
      1. Pedestals may be used to support temporary structures such as construction trailers.
   c. **Mounting.**
      1. Pedestal may be mounted on concrete pads or directly on the ground.
   d. **Security.**
      1. Pedestals shall be secured via hasp or padlock, as stipulated by OIT.
   e. **Cables supported.**
      1. Pedestals shall not house more than 4 cables.

4. **Cabinets.**
   a. Cabinets are not used in campus backbone OSP infrastructure.

5. **Vaults.**
   a. Vaults are not used in campus backbone OSP infrastructure.

B. **OSP Trunk (backbone) Pathways.**
   1. **Underground conduits.**
      a. **General description.**
         1. Underground conduits are the required pathway in main campus conduit system runs, also known as the IT campus backbone.
      b. **Material.**
         2. Use Trade Size 4, 4” conduits, OIT shall specify the number of conduits to be placed in each run.
            a) For planning purposes, OSP backbone pathways should range in capacity from 8 to 16 Trade Size 4, 4” conduits.
      c. **Innerduct.**
         1. OIT may specify Carlon Multi-Gard multiple cell PVC in lieu of innerduct installed in Schedule 40 conduits. Carlon Multi-Gard PVC Type C, Schedule 40 outer shell with four 1.25” multiple cells (innerduct maximum inside diameter is 1.19” and the maximum outside diameter is 1.31”) is the standard prefabricated innerduct used on campus, as illustrated in the picture.
         2. OIT may alternately specify Maxcell Innerducts in lieu of Carlon Multi-Gard. Each Trade Size 4 conduit shall have two (2) 4” 3-cell Maxcell Innerducts placed in it, as specified by OIT. Maxcell Innerducts are factory lubricated and have pull tapes are pre-installed.
      d. **Length.**
1) No section of underground conduit shall exceed 600’ between pulling points (i.e. MH or HH).

e. Depth.
   1) Place the tops of underground conduits a minimum of 48” below grade.

f. Loading.
   1) Construct Underground conduits to dissipate H-20 static or dynamic loads.

g. Electrical underground clearances.
   1) The minimum clearance between electrical conduits and underground IT conduits is 12” of well-tamped earth or 3” of concrete.

h. Foreign structure underground clearances.
   1) The minimum clearance for parallel underground foreign structures such as gas, oil, or water pipelines is 12” of well-tamped earth. The minimum clearance for crossing underground foreign structures is 6” of well-tamped earth.

i. Water infiltration and seepage mitigation.
   1) Place MH- or HH-to-building underground conduit runs uphill so that water infiltration and seepage flows to the MH or HH, as shown in the sketch below. That is, all conduits entering a building shall be pitched to drain away from the building. A minimum drain slope of 12.5” per 100’ (0.125 inch per foot) is required when extending conduits away from building structures. Bow MH-to-MH conduit runs upwards to preclude MH-to-MH water infiltration and seepage, as illustrated below. A minimum drain slope of 12.5” per 100’ shall extend from the middle of the span to each MH. Conduits entering a window’s bell shall also be compound sealed.

j. Vacant conduit sealing.
   1) Seal vacant conduits with duct plugs at all MHs, HHs, and building entrance points to preclude water infiltration and seepage. Provide adjustable duct plugs with a metal base and a screw-type expandable outer rubber surface.

k. Bends.
   1) There shall be no more than the equivalent of two 90-degree bends, or 180-degrees total, between pulling points, including kicks (a pipe bend of less than 45-degrees made to change the pipe’s direction) and offsets (two mirror-image bends made to avoid an obstruction). Use manufactured bends where possible. Back-to-back 90-degree bends placed closer together than 10’ shall be avoided.

l. Sweeps.
   1) Sweeps are preferred to 90-degree bends. Trade Size 4, 4” conduit sweeps should possess a minimum 48” bend radius.

m. Diverts.
   1) Limit the maximum divert or change in direction in any plane between lengths of straight rigid conduit without the use of bends or sweeps to 5 degrees.

n. Pulling tape.
   1) Equip each underground conduit with a minimum 3/8” diameter pulling tape, rope, or strap with a rated tensile strength meeting or exceeding 2500 pounds. Pull rope tails of a minimum of 36” shall be secured at the end of each conduit.

o. Measuring tape.
   1) Provide a pre-lubricated conduit measuring tape in at least one conduit in every run. The conduit measuring tape shall be waterproof with permanent printed footage.

p. Encasement.

**OSP water infiltration and seepage mitigation construction rules**

![Diagram](image)
1) Encase all underground conduits in minimum 2500 PSI concrete with #4 rebar run parallel with the conduit on all four corners. Minimum thickness of the concrete encasement top shall be 4 inches. Permanently dye the concrete encasement orange or red. A typical main campus conduit system run (campus backbone) is shown below.

q. Warning tape.
   1) Place orange detectable warning tape within 12” to 18” of the surface for the length of the underground conduit run.

r. Conduit supports.
   1) Pre-manufactured conduit support saddles/seats are required. Allow a minimum of 2” between conduits and a minimum of 3” of perimeter concrete encasement.
Saddle supports shall be interlocked and placed a minimum of every 5’ along the entire run. The conduits shall be staked down at each saddle and #3 crossties installed.

s. Soil compaction.
   1) After encasement, backfill the trench with native soil in lifts no greater than 12”. Mechanically compact the replaced soil by tamping so as to maintain a minimum relative density of 95 percent, which is considered “well-tamped.” The university shall conduct field tests to verify compaction compliance in accordance with ASTM D 2922 (Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)), ASTM D 1556 (Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method), or ASTM D 2167 (Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method).

t. Certification and commissioning.
   1) Test all underground conduits prior to commissioning. Certify underground conduits by pulling a mandrel through them. The mandrel shall be equivalent to the nominal inside conduit diameter and not less than 12” long. If the mandrel does not pass through the conduit, the conduit shall be repaired or replaced at the failure point. OIT personnel shall witness the certification test and commission the underground conduits in writing.

u. Documentation.
   1) Deliver As-builts of the underground conduit OSP system to OIT, in the prescribed format and media.

2. Direct buried cables.
   a. General.
      1) Direct buried cable is placed under the ground surface in such a manner that it cannot be removed without disturbing the soil.
   b. Limited campus use.
      1) Direct buried infrastructure is suitable for use in short-term infrastructure such as construction trailers.
   c. Marking.
      1) Direct buried cable shall be marked every 50’ along its run length to preclude inadvertent damage during project construction. The run length markings may be stakes, placards, or other suitable signage.
   d. Depth.
      1) Place direct buried cable a minimum of 24” below grade.

3. Aerial pathways.
   a. Aerial pathways shall not be used on campus, without prior approval by OIT.

C. Building In-tract pathways to campus Trunk (backbone) spaces.
   1. Place a minimum of two Trade Size 4, 4” conduits to the nearest MH or as specified by OIT.
   2. Place a second, redundant pathway of a minimum of two Trade Size 4, 4” conduits to a nearby MH as specified by OIT.
   3. In-tract pathways should be placed, encased, and marked as per the OSP Trunk pathways described above.
   4. Media placed to support the building is provided by a separate contract managed by OIT, as described below.

D. OSP Media.
   1. All OSP media is provided by the OIT department under a separate project and contract.
   2. Fiber media.
      a. Between the campus core and each distributed building or structure, 72 strands of single mode fiber (SMF) are typically placed, or as directed by OIT.
         1) Maximum connector loss per mated pair: 0.75 dB.
         2) Maximum splice loss: 0.3 dB.
         3) Maximum cable attenuation at 1310 nm and 1550 nm: 1.0 dB/km.
4) Minimum return loss: 35 dB.
   b. Angled polished connectors (APC) may be required for specialized applications, as specified by OIT.
      1) APC should possess an angle of 8°, an insertion loss of 0 to 0.5 dB, and an optical return loss of 60 dB.
   3. Copper media may be placed to support telephony and other low voltage circuitry. The numbers of pairs placed is reflected in the structure’s predicted load, as specified by OIT. Depending upon distance, 22 (0.64 mm) or 24 (0.5 mm) AWG copper wire may be required.
   4. OSP media is labeled according to the campus standard, as specified by OIT.

E. Street marking for OSP.
   1. Use the APWA uniform color code [ANSI Z535.1] for marking excavation sites and underground facilities in conflict with an excavation.

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Proposed Excavation</td>
</tr>
<tr>
<td>Pink</td>
<td>Temporary Survey Markings</td>
</tr>
<tr>
<td>Red</td>
<td>Electric Power Lines, Cables, Conduit and Lighting Cables</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas, Oil, Steam, Petroleum or Gaseous Materials</td>
</tr>
<tr>
<td>Orange</td>
<td>Communication, Alarm or Signal Lines, Cables or Conduit</td>
</tr>
<tr>
<td>Blue</td>
<td>Potable Water</td>
</tr>
<tr>
<td>Purple</td>
<td>Reclaimed Water, Irrigation and Slurry Lines</td>
</tr>
<tr>
<td>Green</td>
<td>Sewers and Drain Lines</td>
</tr>
</tbody>
</table>

END OF SECTION 27 05 43
SECTION 27 32 53 - EMERGENCY TELEPHONES

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. Section 27 32 53 describes the codes, standards, specifications, recommendations, and practices required for emergency telephone placement and installation at the University of Colorado Denver | Anschutz Medical Campus (the university) including Free Standing Emergency Pole (FSEP) and Emergency Service Phones (ESP). Section 27 32 53 applies to all university campuses.

B. The project general contractor (GC) is responsible for installing emergency poles as per the requirements described in this document. The Office of Information Technology (OIT) is the approving authority at the downtown Auraria campus. University Police is the approving authority at Anschutz Medical Campus. Corrections, comments, questions, or omissions about this standard shall be submitted to OIT and the University Police via the university project manager.

C. Planning.
   1. To facilitate expansion of emergency communications services, the architect/engineer shall provide to OIT floor plan drawings for new building construction and major renovation projects during design and at construction for downtown Auraria campus projects or the University Police for AMC projects. CAD drawings of the Electrical/Communications plans shall be provided to OIT or the University Police upon release of construction document through the university project manager. These documents will serve as a baseline for emergency communications build out and expansion.
   2. The preliminary plans, indicating service locations and space requirements, will be returned to project managers for inclusion in the final plans.

D. Consult with OIT or the University Police for the following.
   1. Acceptability for specific substitutions of specified products.
   2. Guidance in the application of a standard or specification in a non-listed or design situation.
   3. Approval for deviation from standards and specifications or industry-standard methods and procedures if indicated by special circumstances.

E. Workmanship. All materials and equipment shall be installed in accordance with recommendations of the manufacturer as approved by the architect, to conform to initial design requirements or specification’s and contract documents.

1.3 SUBMITTALS

A. General Description and Requirements
   1. In addition to the requirements noted herein, refer to Division 1 Specification for additional requirements. As a minimum, Contractor shall ensure all requirements listed here are met.
   2. Within 45 days after award of contract or as dictated by the construction schedule (whichever period of time is shorter), the Contractor shall submit prefabrication submittals consisting of
product data and shop drawings for approval. Partial submittals will not be accepted without prior written approval from the Architect.

3. Review of the Prefabrication Submittals by the Architect is for purposes of tracking the work and contract administration and does not relieve the Contractor of responsibility for any deviation from the Contract Documents, or from providing equipment and/or services required by the Contract Documents which were omitted from the prefabrication submittals.

4. No portion of the project shall commence nor shall any equipment be procured until the prefabrication submittals have been approved in writing by the Architect. All installations shall be in accordance with the Contract Documents.

5. A detailed completion schedule shall be submitted with the prefabrication submittals.

6. Prefabrication submittals shall be accompanied by a letter of transmittal identifying the name of the project, Contractor's name, date submitted for review, and a list of items transmitted.

B. Product Data:
1. Compliance Matrix: Provide full specification compliance matrix as described in the Specification Response section of this specification section.
2. Warranty Information: Provide all warranty information as described in this specification section for review and approval.
3. Component List: Provide complete submittal component list at the beginning of the submittal package. Component list shall identify each component name, manufacturer, and specific product/part number. All part numbers shall clearly indicate special options, color, accessories, etc. Component list and manufacturer cut-sheets shall be compiled to match the order of each Appendix.
4. Cut-Sheets: Submit manufacturer’s cut-sheets on all components listed within this specification and corresponding appendix. All components and parts being used shall be highlighted in color on cut-sheets to distinguish specific product/part numbers, options, colors, accessories, etc.

C. Prefabrication Shop Drawings:
1. Symbol Legend, Abbreviations, and Description: Provide drawings including descriptions of all abbreviations, symbols, typical mounting heights, project information, etc.
2. One-Line Wiring Diagrams: Include one-line wiring diagrams indicating all backbone and horizontal cabling, copper pair and fiber strand counts, cable quantities, splice enclosures, etc.
3. Site Plan: Provide complete site and exterior plans indicating all site and building façade mounted communication device outlets, equipment, and components proposed to be installed. Additionally, manholes, pull-boxes, and all major raceway routing shall be indicated for conduits 2-inches and larger. Shop drawings shall represent final conduit routing and manhole and/or pull-box placement as coordinated and/or confirmed with Service Provider, Civil Engineer and other trades.
4. Floor Plans: Indicating all communication device outlets, equipment, and components proposed to be installed. Floor plans shall indicate cable routing origin and labeling scheme for each cable and termination position. Additionally, major raceway routing shall be indicated for cable trays and conduits 2-inches and larger, based on final coordination with all other trades. Shop drawings shall clearly indicate areas with cable tray clearance limitations and/or other cable access limitations for review and approval by the university, Architect, and Engineer.
5. Drawing Scale: Shop drawings shall be drawn to scale and completely dimensioned as to clearly show construction detail.
6. Labeling: Provide documentation of all labeling schemes for conduit, back-boxes, cables, outlets, wiring blocks and/or patch panels, device faceplates, etc.
7. Documentation: Provide a minimum of (1) hardcopy set of prints (in addition to electronic copies) for review or as indicated in Division-1 general conditions.

1.4 QUALITY ASSURANCE

A. The following table of codes, standards, specifications, recommendations, and methods and procedures are applicable to the provisioning of emergency poles at The University. They are incorporated by reference. The most current version is referenced.
EMERGENCY TELEPHONES

1.5 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.
1.10 DEFINITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: subject to requirements, provide products by the following:
1. Communications Poles
   a. Code Blue – CB-1d at the Anschutz Medical Campus
   b. Talk-A-Phone at the downtown Auraria campus
2. Emergency Service Phones
   a. Provided by the university

PART 3 - EXECUTION

3.1 EMERGENCY POLE INSTALLATION REQUIREMENTS

A. Free Standing Emergency Pole (FSEP) Placement.
1. Free Standing Emergency Poles (FSEP) are placed to provide ready access to emergency services. OIT or the University Police shall be consulted with prior to the placement of any FSEP.
2. No joint use. Joint use of FSEP infrastructure is prohibited. FSEP infrastructure is not shared with other utilities except those needed to directly support FSEP requirements including WIFI and video surveillance.
3. FSEPs shall be thoughtfully placed so they do not impact sidewalk or parking lot snow removal or pedestrian traffic flow.

B. Installation Practice.
1. Safety. Follow all campus safety policies when installing FESP. FSEP may be placed near high vehicular traffic areas. Care should be used when working in congested areas.
2. FSEP designator. Campus emergency poles shall be assigned a designator by OIT or University Police to aid in maintenance and repair.
3. Venting air gap. Installers shall provide a minimum ½-inch air gap between the concrete base and the FSEP pedestal. This gap facilitates moisture (dew) evaporation. A venting gap of no larger than 1 inch is desired. A gap larger than 1 inch would possibly allow snow, dust, and trash to blow into the FSEP. Larger gaps would also allow rodents to nest in the pole.
4. Grounding rod. A grounding rod shall be placed in each concrete pad that supports a FSEP pedestal. The copper grounding rods shall be a minimum ½ inch in diameter by 8 feet in length. Bond and ground all metallic parts to the grounding rod with a minimum 6-AWG insulated, green conductor.
5. IT conduits. OIT requires one Trade Size 2, 2-inch conduit to support voice and data connectivity to the FSEP. Conduit is to be sized to support wireless access point video surveillance cameras.
6. Electrical conduits. One Trade Size 1, 1-inch conduit shall be placed to support the FSEP power requirements.
7. Electrical service. Place a dual gang four-plex 120V, 20A electrical box in the lower portion of each FSEP. The receptacle shall be a minimum of 8 inches above the base.
8. Conduit depth. The tops of underground conduits supporting FSEP installations shall be placed a minimum of 30 inches below grade.
9. Direct buried cables. Direct buried cable shall be placed a minimum of 24 inches below grade, if used.
10. Water infiltration and seepage mitigation. FSEP conduits shall be sealed to preclude water infiltration and seepage. Conduit runs serving FSEPs shall be placed so that water infiltration and seepage flows away from buildings and towards maintenance holes or handholes. A minimum
11. Electrical underground clearances. The minimum clearance between electrical conduits and underground IT conduits is 12 inches of well-tamped earth or 3 inches of concrete. Joint trenches are permitted if these clearances can be maintained.

12. Foreign structure underground clearances. The minimum clearance for parallel underground foreign structures such as gas, oil, or water pipelines is 12 inches of well-tamped earth. The minimum clearance for crossing underground foreign structures is 6 inches of well-tamped earth.

13. Conduit bends. There shall be no more than the equivalent of two 90-degree bends, or 180-degrees total, between pulling points, including kicks (a pipe bend of less than 45-degrees made to change the pipe’s direction) and offsets (two mirror-image bends made to avoid an obstruction). Manufactured bends shall be used where possible. Back-to-back 90-degree bends placed closer together than 10 feet shall be avoided.

14. Sweeps. Sweeps are preferred to 90-degree bends. Trade Size 2, 2-inch conduit sweeps should possess a minimum 24-inch bend radius.

15. Diverts. The maximum divert or change in direction in any plane between lengths of straight rigid conduit without the use of bends or sweeps shall be limited to 5 degrees.

16. Soil compaction. The trench shall be backfilled with native soil in lifts no greater than 12 inches. The replaced soil shall be mechanically compacted by tamping to maintain a minimum relative density of 90 percent.

17. Certification and commissioning. All underground conduits shall be tested prior to commissioning. Underground conduits shall be certified by pulling a mandrel through them. The mandrel shall be equivalent to the nominal inside conduit diameter. If the mandrel does not pass through the conduit, the conduit must be repaired or replaced at the failure point. University personnel shall witness the certification test and commission the underground conduits in writing.

18. Warning tape and markings. Orange detectable warning tape shall be placed within 12 inches to 18 inches of the surface for the length of the IT underground conduit run used to support FSEP. Red detectable warning tape shall be placed within 12 inches to 18 inches of the surface for the length of the electrical underground conduit run used to support FSEP. Use red detectable tape if a joint trench was used.

19. FSEP installation documentation. As-builts of the installed FSEPs shall be delivered to OIT or the University Police, in the prescribed format and media.

C. ADA Telephony Requirements.

1. Access pad. The FSEP shall have a minimum clear access pad of 30 inches by 48 inches in front of the operational part of the pole as shown in the sketch.

2. The highest operational part of the FSEP shall be no higher than 48 inches above the ground (access pad).

3. Barriers to FSEP access by wheelchairs, crutches, and walkers shall be eliminated. Curbs, rough terrain, unpaved access pads; etc. shall be avoided when placing a FSEP.

4. The FSEP installation shall comply with the following ADA side reach requirements.
   a. Maximum side reach height shall be 54 inches.
   b. Minimum side reach height shall be 9 inches.
   c. Maximum side reach height over an obstruction that is 24 inches wide and 34 inches high shall be 46 inches.
5. The FSEP installation shall comply with the following ADA front reach requirements.
   a. Maximum forward reach height shall be 48 inches.
   b. Minimum forward reach height shall be 15 inches.
   c. Maximum front reach height over an obstruction shall be 44 inches.

D. Communications Media.
   1. All FSEP communications media is provided by the OIT department and is managed under a separate contract.
   2. Fiber optic media. OIT shall place 6 strands of single mode fiber (SMF) or 6 strands of 50-micron multimode fiber (MMF) to the FSEP, as required by distance and application.
   3. Copper media. OIT shall place 6-pairs of copper wire to each FSEP. Depending upon distance, 22 (0.64 mm) or 24 (0.5 mm) AWG shall be used. The outside plant copper cable shall be shielded twisted pair (STP) or other copper media as selected by OIT. OIT will bond and ground all copper media entering campus buildings.
   4. Phone line current. To reliably operate, the Code Blue phone requires a minimum of 20mA line current.

E. Installation Examples.
   1. Picture 1, as shown below, shows a properly installed FSEP. It has an access pad exceeding 48 inches by 30 inches in front of the operating panel. The highest operable mechanism is below 48 inches. Finally, it has a ½-inch to 1-inch gap at its base to facilitate moisture evaporation.
2. Picture 2, below, illustrates an improperly installed FSEP. The FSEP does not have an ADA compliant access pad in front of the operating panel. The pad space is too small. Additionally, the highest operating mechanism exceeds 64 inches in height, well above the ADA required 48 inches. The FSEP does have a ½-inch air gap at its base to facilitate moisture evaporation.

3. Picture 3, on the next page, shows an improperly installed FSEP. The FSEP does not have an ADA compliant access pad in front of the operating panel. Additionally, the highest operating mechanism exceeds 48 inches in height. Finally, the FSEP does have a ½-inch air gap at its base to facilitate moisture evaporation.

4. Picture 4 is presented below. It portrays an improperly installed FSEP. The FSEP does not have ADA compliant access. That is, the 360-degree curb prevents access by wheelchairs. Additionally, the access pad in front of the operating panel is inadequate.

5. Picture 5, as shown below, is an improperly installed FSEP. The FSEP lacks a minimum ½-inch air gap to prevent moisture build up inside the pole. Note the apparent seepage.
3.2 EMERGENCY SERVICE PHONE (ESP) INSTALLATION (RED PHONES) REQUIREMENTS

A. Emergency Services Phone (ESP) Placement.
   1. Emergency Service Phones or red phones are to be placed to provide ready access to emergency services. They are to be placed 1 per floor near common areas including elevator lobbies and bathrooms. Larger floor plates may require 2 locations per floor. OIT will designate the placement of ESP red phone locales.

B. Installation Practice.
   1. IT conduits and back-boxes. OIT requires one Trade Size 1, 1-inch conduit to support voice connectivity to the ESP. Backbox shall be 2-gang deep with single gang mud ring.

C. ADA Telephony Requirements.
   1. The ESP installation shall comply with the following ADA side reach requirements.
      a. Maximum side reach height shall be 54 inches.
      b. Minimum side reach height shall be 9 inches.
      c. Maximum side reach height over an obstruction that is 24 inches wide and 34 inches high shall be 46 inches.

   2. The ESP installation shall comply with the following ADA front reach requirements.
      a. Maximum forward reach height shall be 48 inches.
      b. Minimum forward reach height shall be 15 inches.
      c. Maximum front reach height over an obstruction shall be 44 inches.

D. Communications Media.
   1. All ESP communications media is provided by the OIT department and is managed under a separate contract.

END OF SECTION 27 32 53
SECTION 27 40 00 – AUDIO-VIDEO SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUBMITTALS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.5 SEQUENCING AND SCHEDULING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 PROJECT SITE CONDITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 WARRANTY

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 SPECIFICATION RESPONSE

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 DEFINITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Subject to compliance with requirements provide products by the following:

1. Cables:
   a. Video Coax: (Conduit) 8281A Belden, or equal
   b. Video Coax: (Plenum) 88281 Belden, or equal
   c. Audio: (Conduit) 8762 Belden, or equal
d. Audio: (Plenum) 88761 Belden, or equal

e. Speaker Cable: 9717 Belden or equal

f. RGB Coax Cables: 308-319-1167A

g. RGB Coax Cables: 1167B Belden

h. RGB Coax Cables: V4-3C

i. (a,b,c) Equivalent: Anixter

j. (a,b,c) Equivalent: Carol

k. (a,b,c) Equivalent: Manhattan

l. (a,b,c) Equivalent: Chester

m. AT&T 62.5/125 micron, FDDI, grade fiber terminated in ST connectors

n. Structured Cabling For DigitalMedia & HDBaseT: Crestron DM-CBL-8G-P

o. Crestron Control Network Cabling: Cresnet-P

2.2 APPROVED INSTALLERS/INTEGRATORS

A. Xcite Audiovisuals – 7167 S. Alton Way, Centennial, CO 80112 (720-771-1011) Contact: Brian Seid (brian@xciteav.com)

B. Ford AV – 4230 Carson Street, Denver, CO 80239 (720-374-2345) Contact: Eric Paulsen (paule@fordav.com)

C. AVI/SPL – 15700 Parkerhouse Road, Suite 200, Parker, CO 80134(303-792-3090) Contact: Howard Zucker (howard.zucker@avispl.com)

PART 3 - EXECUTION

A. System Performance Requirements

1. General:

   a. The University Office of Information Technology - Technology Support Services has been assigned responsibility for providing audiovisual services to the University entities. This includes, but is not limited to: audio systems, video systems, integrated audiovisual control systems, and audio/video distribution systems. This includes determining suitability of proposed uses, compliance with appropriate codes and standards, periodic removal and/or replacement of components and extensions or additions to distribution systems.

   b. The Technology Support Services office will work with all the The University entities to assist in the audiovisual design of classrooms, distance learning classrooms, lecture halls, control/monitoring rooms and conference rooms as needed for the The University campus and shall be consulted extensively during the project design through the The University Project Manager.

2. Procedures:

   a. To facilitate provisioning of audiovisual design services to the The University entities, The University Facilities Projects will provide the Technology Support Services Office with preliminary floor plan drawings for all new building construction and/or major remodel projects.

   b. Technology Support Services engineering staff members will meet with new building occupants, audiovisual system end-users, The University Facilities Planning and other interested parties to determine audiovisual needs and/or requirements.
c. The preliminary floor plans provided to the Technology Support Services will be marked to show service locations and space requirements and will be returned to Facilities Planning for inclusion in final plans.

3. Classrooms:

a. Each audiovisual classroom may be connected to a central audio / video distribution room, patching and/or routing system as required. Connections to and from each classroom should include, but not be limited to: (2) RG-6 coaxial cables, (2) CAT5/6 UTP cables, and 2 fiber-optic cables. Infrastructure for this location shall be a triple-gang low voltage electrical box mounted at receptacle height with (2) 1.25” EMT conduits extending to an accessible location above ceiling. These distributed connections may not be required for all AV installations due to emerging and proliferating videoconference bridging technologies on campus, and will be specified as required by Technology Support Services. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

1) Liberty/PanelCrafters – Standard and Custom Fabricated
2) BTX Technologies, Inc – Standard and Custom Fabricated
3) Extron – AAP/MAAP Standard Plate Modules

b. Each classroom shall include on the front wall a LAN / Telco “A / B” jack per campus IT standard. These network lines must be installed by or under the direction and control of The University Office of Information Technology. There shall be located directly adjacent to this “A/B” jack, a duplex power receptacle and audiovisual input plate. Infrastructure for this location shall be a single-gang, low voltage electrical box mounted at standard receptacle height, with (1) .75” EMT conduit extending to an accessible ceiling location. This requirement may be in lieu of, or in addition to, connectivity of an instructor podium / instructor desk via an audiovisual floor box.

c. Each classroom will have a dedicated audiovisual input plate for connection of presenter computers and other audiovisual presentation sources as required. A dedicated audiovisual input plate shall be installed on the front wall of the room directly adjacent to a LAN / Telco jack and duplex receptacle. Additional audiovisual input locations may be required depending on the layout and specific need for each classroom. Each classroom audiovisual input plate location shall be triple-gang low-voltage electrical box, with (2) 1.25” EMT conduits extending to an accessible location above ceiling. This requirement may be in lieu of, or in addition to, connectivity of an instructor podium / instructor desk via an audiovisual floor box. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

1) Liberty/PanelCrafters – Standard and Custom Fabricated
2) BTX Technologies, Inc – Standard and Custom Fabricated
3) Extron – AAP/MAAP

d. Each classroom shall include a ceiling mounted projection screen or projection screen(s) depending on the size dimensions and viewing requirements for the audience. Recommended projection screen size is to be determined with the following formula: Maximum viewing distance from the screen to the furthest viewer divided by / 6 = recommended screen height. All projection screens shall be widescreen 16:10, 16:9, or 15:10 aspect ratio. The bottom of the projection screen may extend no less than 40” AFF for adequate audience viewing. Projection Screens should be ceiling and/or wall mounted to extend in front of classroom whiteboards, chalkboards, and etcetera wall obstacles. All projection screens shall be motorized electric models. Screen motors shall include integrated low voltage control interfaces and low voltage
control wall switches for external/remote operation. Infrastructure for the screen switch location includes a single-gang low voltage box mounted at standard switch height with a single .75” EMT conduit extending above ceiling to an accessible location. The low voltage screen switch shall be installed in close proximity to the room entry lights and system control panel. Screen electrical junction boxes shall be installed in an accessible ceiling location. Acceptable projection screen models include but are not limited to:

1) Da-Lite - Tensioned Advantage Electrol w/ Integrated LVC  
2) Da-Lite - Advantage Electrol w/ Integrated LVC  
3) Da-Lite – Tensioned Contour Electrol w/ Integrated LVC

e. Each classroom shall include a ceiling mounted LCD graphics projector or projector(s) depending on the size dimensions and viewing requirements for the audience. All graphics projectors shall be widescreen 16:10, or 15:10 aspect ratio with a minimum (WXGA 1280x800) native resolution. All graphics projectors should be of adequate brightness and contrast to overcome standard classroom ambient lighting conditions. LCD projectors 3000 ANSI lumens and above are specifically required for all classrooms. Infrastructure for this location includes an un-switched duplex power receptacle to be located in an above ceiling plenum enclosure, located directly above, or adjacent to the projector mounting location. Additional infrastructure includes building network connectivity via The University standard “A/B” (surface mount) data jack to be located in an above ceiling plenum enclosure located directly above, or adjacent to the projector mounting location. Graphics projector models include, but are not limited to:

1) Panasonic – PT-EW550U / EW730ZU / EZ590U – 4000-7000 Lumen, WXGA  
2) Panasonic – PT-LW 312U / 330U / FW430U – 3000-4000 Lumen, WXGA  
3) NEC – PA-571W / 672W / 452W – 4000-7000 Lumen, WXGA  
4) NEC – ME-M301W / 331W / 401W - 3000-4000 Lumen, WXGA

All ceiling projectors are to be securely mounted using The University standard mounting hardware. Suspended ceiling tile-bridge mounts are acceptable for mounting projectors of less than 35 pounds. All tile bridge mounts must be securely tied to the ceiling structure. All mounting points included with the ceiling tile bridge must be secured. All projectors should be mechanically mounted to be center aligned with the projection screen. Mechanical, horizontal and vertical lens shift may be used to optimize the image. Digital keystone and pixel correction options are not acceptable options to overcome mechanical mounting alignment errors. Acceptable projector mounting hardware models include:

1) Chief Manufacturing – RPMA Projector Mount Bracket  
2) Chief Manufacturing – CMS Series Mounting Hardware

All ceiling projector accessories and equipment, such as HDBaseT receivers, video baluns, audio amplifiers, power supplies, etc. must be mounted and secured in an accessible above ceiling plenum enclosure. Visible below ceiling connections to the projector must be cleanly installed, without AV devices mounted to the top of the projector, or to the projector mounting pole, etc. Duplex power and A/B data jacks described above, shall be coordinated and installed along with the plenum ceiling enclosure and required AV devices. The plenum ceiling enclosure shall be sized appropriately for the project. Acceptable ceiling projector plenum enclosure models include:

1) Chief Manufacturing – CMA-470 / 471 / 472  
2) Chief Manufacturing – CMS-491P2 / CMS492CP2  
3) FSR – CB-12 / 22 / 224

All ceiling projectors shall be locked for security from theft. A key-locking, anti-theft alarm shall be professionally installed at each ceiling projector location. All alarm keys must be coordinated with Technology Support Services for uniformity and ease of service. All alarm
keys shall be labeled and delivered to Technology Support Services at the conclusion of a project or major project phase.

Acceptable security alarm models include:

1) Secure-It – Sonic Shock Alarm 5 (Key # By Campus/Area)

f. Smaller classrooms may include a direct-view television monitor in lieu of, or in addition to, a video projection system depending on the size dimensions and viewing requirements for the audience. All direct-view televisions shall be widescreen 16:9, 16:10, or 15:10 aspect ratio with a minimum 1080p native video resolution. Infrastructure for this location includes an un-switched, duplex power receptacle to be located inside a recessed AV enclosure directly behind the television location at 72” AFF to box center. A wall mount, recessed AV equipment enclosure shall be installed behind each television location, at 72” AFF to box center. (1) 1.25” EMT conduit shall extend from the recessed AV box to above ceiling, in an accessible location. A duplex receptacle and LAN / Telco “A/B” jack, shall be installed inside each recessed wall box. See TV wall box specifications, below. Acceptable television models include, but are not limited to:

1) Sharp - Aquos LC Series Televisions
2) Samsung – UN Series

All direct-view television displays are to be securely wall-mounted using The University standard mounting hardware. Television mounts must be secured to metal wall-studs not more than 16” from center to center with Hilti ¼” HTB Hollow Wall Anchors. All supplied hardware mounting points must be securely anchored to studs. Wall backing may be required as necessary under direction from Technology Support Services. Ceiling mount installation of direct-view displays is not preferred, although it may be required in unique situations as necessary, under direction from Technology Support Services. Acceptable television mount models include:

1) Chief Manufacturing – LTM, XTM Fusion Series Tilt Wall Mounts
2) Chief Manufacturing – MWR Series Swing-Arm Wall Mounts

All classroom television locations must include a deep, recessed, wall enclosure for electrical infrastructure, data infrastructure, and AV devices. The recessed wall enclosure should be adequately sized for the project. Acceptable wall recessed TV boxes include:

1) Chief Manufacturing – PAC-525 / 526
2) FSR – PWB-100 / 200 / 250 / 450

g. Sound reinforcement systems shall be built into larger classrooms as required. A pair of surface mount speakers shall be installed on the front wall or ceiling of each classroom – facing the audience. Wall mounted speakers shall require a single-gang low-voltage electrical box mounted directly behind the speaker location at 96” AFF with (1) .75” EMT conduit extending to above ceiling in an accessible location. Depending on the size of the classroom, additional distributed 70V ceiling speakers may be employed for adequate sound coverage. Acceptable surface mount speaker models include:

1) JBL – Control Contractor Series Surface Mount Speaker
2) Tannoy – I Series Surface Mount Speaker
3) Tannoy – DI Series Surface Mount Speaker

h. Each classroom shall have a central audiovisual equipment rack location within. Smaller classroom designs may locate equipment within a multimedia podium/lectern. Larger systems may require an external wall-mount or floor-standing equipment rack. All AV rack locations shall include a dedicated 20A duplex receptacle with no shared ground or neutral electrical
wiring. All AV equipment rack locations shall at minimum include an 8” x 8” screw cover (Hoffman Type) pull box with (3) 1.25” EMT conduits extending to above ceiling in an accessible location. The rack pull box shall be located adjacent to the dedicated 20A duplex receptacle. Mounting heights for wall rack electrical/pull boxes shall be 50” AFF. Mounting heights for floor-standing equipment racks shall be standard receptacle height. Acceptable equipment rack models include, but are not limited to:

1) Middle Atlantic – WRK Series Floor Standing Equipment Rack  
2) Middle Atlantic – ERK Series Floor Standing Equipment Rack  
3) Middle Atlantic – DWR Series Sectional Wall Mount Equipment Rack  
4) Middle Atlantic – EWR Series Sectional Wall Mount Equipment Rack  
5) Middle Atlantic – WRS Series Low Profile Equipment Rack

i. Each classroom that requires a podium will include an audiovisual floor box, which shall be located directly underneath the podium location. The audiovisual floor box will include knockouts and conduit pathways for dedicated network “A/B”, audio/video cabling, and AC power cabling. A similar layout would be used for other floor box locations as required within the classroom. Acceptable audiovisual floor box models include:

1) Wiremold / Legrand - Evolution 6AT / 8AT Series Poke-Thru Floor Devices  
2) Wiremold / Legrand – RFB4 On Grade Floor Boxes  
3) FSR – FL Series Concrete Pour In / Raised Access Boxes

j. Each classroom shall include a pan/tilt/zoom camera location for the purposes of lecture capture and portable videoconference integration. The camera shall typically be located at the rear or side wall of the classroom with a clear view of the presenter desk / podium location. Infrastructure for this location includes a single-gang, low voltage electrical box mounted at 96” AFF with (1) .75” EMT conduit extending to above ceiling in an accessible location. A duplex receptacle shall be installed directly adjacent to the camera location at 96” AFF.

k. Each typical classroom shall include a wall mounted audiovisual system control panel. Infrastructure for this location includes a triple-gang low voltage electrical box mounted at standard switch height with (1) 1.00” EMT conduit extending to above ceiling in an accessible location. The control panel shall typically be installed adjacent to the low-voltage projection screen switch and room lighting controls. Acceptable audiovisual control panel models include:

1) Crestron – MPC-M5 / M10 / M20 / M25 / M50

l. Classroom lighting zones should be arranged to be dimmable and/or on/off controllable from the front of the room to the rear of the room. Specifically, the first row of classroom lighting shall be on a separate lighting zone so that excessive light does not degrade the quality of the video display systems typically located on the front wall of the classroom. Light switches, dimmer controls, etc. shall typically be mounted at standard switch height in close proximity behind the presenter’s desk / podium, and shall be directly adjacent to the low voltage screen control switch and system control panel.

m. University classrooms will typically include a small teaching stand, or a small-to-medium multimedia podium, to function as a teaching station, equipment rack, equipment storage, etc. depending on need. The podium teaching station and related equipment is almost always the primary AV source in the classroom, and must be built to accommodate the user and the classroom environment. The University has worked with a podium manufacturer to facilitate a master design for classroom podiums, and this manufacturer and master design should be used whenever possible. (See Part 4 Illustration Ex. 1-2) Acceptable podium/stand models include:

1) DWI Enterprises – D20-32 (University of Colorado Custom Spec)  
2) DWI Enterprises – IS-10 (University of Colorado Custom Spec)  
3) Da-Lite – Euro Lecterns
4) Spectrum Industries – LINK Series
5) Spectrum Industries – Inspiration Plus Series

4. Lecture Halls:
   
a. Each audiovisual lecture hall may be connected to a central audio / video distribution room, monitoring room, patching and/or routing system as required. Connections to and from each lecture hall should include, but not be limited to: (2) RG-6 coaxial cables, (2) CAT5/6 UTP cables, and 2 fiber-optic cables. Infrastructure for this location shall be a triple-gang low voltage electrical box mounted at receptacle height with (2) 1.25” EMT conduits extending to an accessible location above ceiling. These distributed connections may not be required in all AV installations due to emerging and proliferating videoconference bridging technologies on campus, and will be specified as required by Technology Support Services. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:
   
   1) Liberty/PanelCrafters – Standard and Custom Fabricated
   2) BTX Technologies, Inc – Standard and Custom Fabricated
   3) Extron – AAP/MAAP Standard Plate Modules

b. Each lecture hall shall include on the front wall a LAN / Telco “A / B” jack per campus IT standard. These network lines must be installed by or under the direction and control of The University Office of Information Technology. There shall be located directly adjacent to this “A/B” jack, a duplex power receptacle and audiovisual input plate. Infrastructure for this location shall be a single-gang, low voltage electrical box mounted at standard receptacle height, with (1) .75” EMT conduit extending to an accessible ceiling location. This requirement may be in lieu of, or in addition to, connectivity of an instructor podium / instructor desk via an audiovisual floor box.

c. Each lecture hall will have a dedicated audiovisual input plate for connection of presenter computers and other audiovisual presentation sources as required. A dedicated audiovisual input plate shall be installed on the front wall of the room directly adjacent to the LAN / Telco jack and duplex receptacle. Additional audiovisual input locations may be required depending on the layout and specific need for each lecture hall. Each lecture hall audiovisual input plate location shall be a triple-gang low-voltage electrical box mounted at standard receptacle height, with (2) 1.25” EMT conduits extending to an accessible location above ceiling. This requirement may be in lieu of, or in addition to, connectivity of an instructor podium / instructor desk via an audiovisual floor box. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

   1) Liberty/PanelCrafters – Standard and Custom Fabricated
   2) BTX Technologies, Inc – Standard and Custom Fabricated
   3) Extron – AAP/MAAP

d. Each lecture hall shall include two or more ceiling mounted projection screens depending on the size dimensions and viewing requirements for the audience. Recommended projection screen size is to be determined with the following formula: Maximum viewing distance from the screen to the furthest viewer divided by / 6 = recommended screen height. All projection screens shall be widescreen 16:10, 16:9, or 15:10 aspect ratio. The bottom of the projection screen may extend no less than 40” AFF for adequate audience viewing. Projection Screens should be ceiling and/or wall mounted to extend in front of lecture hall whiteboards, chalkboards, and etcetera wall obstacles. All projection screens shall be motorized electric models. Screen motors shall include integrated low voltage control interfaces and low voltage control wall switches for external/remote operation. Infrastructure for the screen switch location
includes a single-gang, low voltage box mounted at standard switch height with a single .75” EMT conduit extending above ceiling to an accessible location. The low voltage screen switch shall be installed in close proximity to the room entry lights and system control panel. Any screen electrical junction boxes shall be installed in an accessible ceiling location. Acceptable projection screen models include but are not limited to:

1) Da-Lite - Tensioned Advantage Electrol w/ Integrated LVC
2) Da-Lite - Advantage Electrol w/ Integrated LVC
3) Da-Lite – Tensioned Contour Electrol w/ Integrated LVC

e. Each lecture hall shall include two or more ceiling mounted LCD graphics projectors depending on the size dimensions and viewing requirements for the audience. All graphics projectors shall be widescreen 16:10, or 15:10 aspect ratio with a minimum (WXGA 1280x800) native resolution. Projectors with high resolution (1920 x 1200), and high brightness (7000-10000 Lumens) may be required in the Lecture Halls depending on application and architectural considerations. All graphics projectors should be of adequate brightness and contrast to overcome typical lecture hall ambient lighting conditions. LCD projectors 5000 ANSI lumens and above are specifically required for all lecture halls. Infrastructure for this location includes an un-switched duplex power receptacle to be located in an above ceiling plenum enclosure, located directly above, or adjacent to the projector mounting location. Additional infrastructure includes building network connectivity via The University standard “A/B” (surface mount) data jack to be located in an above ceiling plenum enclosure located directly above, or adjacent to the projector mounting location. Acceptable graphics projector models include, but are not limited to:

1) Panasonic – PT-EW730ZU – 7000 Lumens, WXGA
2) Panasonic - PT-EW650U - 5800 Lumens, WXGA
3) Panasonic - PT-EZ590U - 5000 Lumens, WUXGA
4) Panasonic - PT-DZ780BU - 7000 Lumens, WUXGA

All ceiling projectors are to be securely mounted using The University standard mounting hardware. Suspended ceiling tile-bridge mounts are acceptable for mounting projectors of less than 35 pounds. All tile bridge mounts must be securely tied to the ceiling structure. All mounting points included with the ceiling tile bridge must be secured. All projectors should be mechanically mounted to be center aligned with the projection screen. Mechanical, horizontal and vertical lens shift may be used to optimize the image. Digital keystone and pixel correction options are not acceptable options to overcome mechanical mounting alignment errors. Acceptable projector mounting hardware models include:

1) Chief Manufacturing – RPMA Projector Mount Bracket
2) Chief Manufacturing – CMS Series Mounting Hardware

All ceiling projector accessories and equipment, such as HDBaseT receivers, video baluns, audio amplifiers, power supplies, etc. must be mounted and secured in an accessible above ceiling plenum enclosure. Visible below ceiling connections to the projector must be cleanly installed, without AV devices mounted to the top of the projector, or to the projector mounting pole, etc. Duplex power and A/B data jacks described above, shall be coordinated and installed along with the plenum ceiling enclosure and required AV devices. The plenum ceiling enclosure shall be sized appropriately for the project.

Acceptable ceiling projector plenum enclosure models include:

3) Chief Manufacturing – CMA-470 / 471 / 472
4) Chief Manufacturing – CMS-491P2 / CMS492CP2
5) FSR – CB-12 / 22 / 224
All ceiling projectors shall be locked for security from theft. A key-locking, anti-theft alarm shall be professionally installed at each ceiling projector location. All alarm keys must be coordinated with Technology Support Services for uniformity and ease of service. All alarm keys shall be labeled and delivered to Technology Support Services at the conclusion of a project or major project phase.

Acceptable security alarm models include:

2) Secure-It – Sonic Shock Alarm 5 (Key # By Campus/Area)

f. Sound reinforcement systems shall be built into lecture halls as required. A pair of surface mount speakers shall be installed on the front wall or ceiling of each lecture hall – facing the audience. Wall mounted speakers shall require a single-gang low-voltage electrical box mounted directly behind the speaker location at 96” AFF with (1) .75” EMT conduit extending to above ceiling in an accessible location. Depending on the size of the lecture hall, additional distributed 70V ceiling speakers may be employed for adequate sound coverage. Acceptable surface mount speaker models include:

1) JBL – Control Contractor Series Surface Mount Speaker
2) Tannoy – I Series Surface Mount Speaker
3) Tannoy – DI Series Surface Mount Speaker

g. Each lecture hall shall have a central audiovisual equipment rack location within. Smaller lecture hall designs may locate equipment within a multimedia podium/lectern. Larger systems may require an external wall-mount or floor-standing equipment rack. All AV rack locations shall include a dedicated 20A duplex receptacle with no shared ground or neutral electrical wiring. All AV equipment rack locations shall at minimum include an 8” x 8” screw cover (Hoffman Type) pull box with (3) 1.25” EMT conduits extending to above ceiling in an accessible location. The rack pull box shall be located adjacent to the dedicated 20A duplex receptacle. Mounting heights for wall rack electrical/pull boxes shall be 50” AFF. Mounting heights for floor-standing equipment racks shall be standard receptacle height. Acceptable equipment rack models include, but are not limited to:

1) Middle Atlantic – WRK Series Floor Standing Equipment Rack
2) Middle Atlantic – ERK Series Floor Standing Equipment Rack
3) Middle Atlantic – DWR Series Sectional Wall Mount Equipment Rack
4) Middle Atlantic – EWR Series Sectional Wall Mount Equipment Rack
5) Middle Atlantic – WRS Series Low Profile Equipment Rack

h. Each lecture hall that requires a podium will include an audiovisual floor box, which shall be located directly underneath the podium location. The audiovisual floor box will include knockouts and conduit pathways for dedicated network “A/B”, audio / video cabling, and AC power cabling. A similar layout would be used for other floor box locations as required within the lecture hall. Acceptable audiovisual floor box models include:

1) Wiremold / Legrand - Evolution 6AT / 8AT Series Poke-Thru Floor Devices
2) Wiremold / Legrand – RFB4 On Grade Floor Boxes
3) FSR – FL Series Concrete Pour In / Raised Access Boxes

i. Each lecture hall shall include one or more pan/tilt/zoom camera locations for the purposes of lecture capture and/or videoconference integration. The cameras shall typically be located on the walls of the classroom with a clear view of the presenter desk / podium location, and the audience participants. Infrastructure for each of these locations includes a single-gang, low voltage electrical box mounted at 96” AFF with (1) 1.00” EMT conduit extending to above ceiling in an accessible location. A duplex receptacle shall be installed directly adjacent to each camera location at 96” AFF.
j. Lecture hall lighting zones should be arranged to be dimmable and/or on/off controllable from the front of the room to the rear of the room. Specifically, the first row of classroom lighting shall be on a separate lighting zone so that excessive light does not degrade the quality of the video display systems typically located on the front wall of the classroom. Light switches, dimmer controls, etc. shall typically be mounted at standard switch height in close proximity behind the presenters desk / podium, and shall be directly adjacent to the low voltage screen control switch and system control panel.

k. University Lecture Halls will typically include a small-to-large multimedia podium, to function as a teaching station, equipment rack, equipment storage, etc. depending on need. The podium teaching station and related equipment is almost always the primary AV source in the lecture hall, and must be built to accommodate the user and the lecture hall environment. The University has worked with a podium manufacturer to facilitate a master design for lecture hall podiums, and this manufacturer and master design should be used whenever possible. (See Part 4 Illustration Ex. 2-3) Acceptable podium/stand models include:

1) DWI Enterprises - D20-32 (University of Colorado Custom Spec)  
2) DWI Enterprises - DM-200 (University of Colorado Custom Spec)  
3) DWI Enterprises - IS-10 (University of Colorado Custom Spec)  
4) Spectrum Industries – Link Lectern

5. Conference Rooms:

a. Each audiovisual conference room may be connected to a central audio / video distribution room, monitoring room, patching and/or routing system as required. Connections to and from each conference room should include, but not be limited to: (2) RG-6 coaxial cables, (2) CAT5/6 UTP cables, and 2 fiber-optic cables. Infrastructure for this location shall be a triple-gang low voltage electrical box mounted at receptacle height with (2) 1.25” EMT conduits extending to an accessible location above ceiling. These distributed connections may not be required for all AV installations due to emerging and proliferating videoconference and bridging technologies on campus, and will be specified as required by Technology Support Services. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

1) Liberty/PanCrafters – Standard and Custom Fabricated  
2) BTX Technologies, Inc. – Standard and Custom Fabricated  
3) Extron – AAP/MAAP Standard Plate Modules

b. Each conference room shall include on the front wall, a LAN / Telco “A / B” jack per campus IT standard. These network lines must be installed by or under the direction and control of CU Denver Office of Information Technology. There shall be located directly adjacent to this “A/B” jack, a duplex power receptacle and audiovisual input plate. Infrastructure for this location shall be a single-gang, low voltage electrical box mounted at standard receptacle height, with (1) .75” EMT conduit extending to an accessible ceiling location. This requirement may be in lieu of, or in addition to, connectivity of conference table audiovisual inputs via an audiovisual floor box.

c. Each conference room will have a dedicated audiovisual input plate for connection of presenter computers and other audiovisual presentation sources as required. A dedicated audiovisual input plate shall be installed on the front wall of the room directly adjacent to the LAN / Telco jack and duplex receptacle. Additional audiovisual input locations may be required depending on the layout and specific need for each conference room. Each conference room audiovisual input plate location shall be a triple-gang low-voltage electrical box mounted at standard receptacle height, with (2) 1.25” EMT conduits extending to an accessible location above ceiling. This requirement may be in lieu of, or in addition to, connectivity of conference table...
audiovisual inputs via an audiovisual floor box. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

1) Liberty/PanelCrafters – Standard and Custom Fabricated
2) BTX Technologies, Inc. – Standard and Custom Fabricated
3) Extron – AAP/MAAP Standard Plate Modules

d. Conference rooms with large central conference tables, will typically include an audiovisual floor box, which shall be located directly underneath the table pedestal location. The audiovisual floor box will include knockouts and conduit pathways for dedicated network “A/B”, audio / video cabling, and AC power cabling. A similar layout would be used for other floor box locations as required under the conference table as needed. Acceptable audiovisual floor box models include:

1) Wiremold / Legrand - Evolution 6AT / 8AT Series Poke-Thru Floor Devices
2) Wiremold / Legrand – RFB4 On Grade Floor Boxes
3) FSR – FL Series Concrete Pour In / Raised Access Boxes

e. Each conference room shall include a ceiling mounted projection screen depending on the size dimensions and viewing requirements for the audience. Recommended projection screen size is to be determined with the following formula: Maximum viewing distance from the screen to the furthest viewer divided by / 6 = recommended screen height. All projection screens shall be widescreen 16:10, 16:9, or 15:10 aspect ratio. The bottom of the projection screen may extend no less than 40” AFF for adequate audience viewing. Projection Screens should be ceiling and/or wall mounted to extend in front of conference room wall obstacles. All projection screens shall be motorized electric models. Screen motors shall include integrated low voltage control interfaces and low voltage control wall switches for external/remote operation. Infrastructure for the screen switch location includes a single-gang, low voltage box mounted at standard switch height with a single .75” EMT conduit extending above ceiling to an accessible location. The low voltage screen switch shall be installed in close proximity to the room entry lights and system control panel. Any screen electrical junction boxes shall be installed in an accessible ceiling location. Acceptable projection screen models include but are not limited to:

1) Da-Lite – Tensioned Advantage Electrol w/ Integrated LVC
2) Da-Lite – Advantage Electrol w/ Integrated LVC
3) Da-Lite – Tensioned Contour w/ Integrated LVC

f. Each conference room shall include a ceiling mounted LCD graphics projector depending on the size dimensions and viewing requirements for the audience. All graphics projectors shall be widescreen 16:10, or 15:10 aspect ratio with a minimum (WXGA 1280x800) native resolution. All graphics projectors should be of adequate brightness and contrast to overcome typical lecture hall ambient lighting conditions. LCD projectors 4000 ANSI lumens and above are specifically required for all conference rooms. Infrastructure for this location includes an un-switched duplex power receptacle to be located in an above the ceiling plenum enclosure, surface located directly above or adjacent to the projector mounting location. Additional infrastructure includes building network connectivity via UCD standard “A/B” (surface mount) data jack to be located in an above ceiling plenum enclosure located directly above, or adjacent to the projector mounting location. Acceptable graphics projector models include, but are not limited to:

1) Panasonic – PT-EW550U / EW730ZU / EZ590U – 4000-7000 Lumen, WXGA
2) Panasonic – PT-LW 312U / 330U / FW430U – 3000-4000 Lumen, WXGA
3) NEC – PA-571W / 672W / 452W – 4000-7000 Lumen, WXGA
4) NEC – ME-M301W / 331W / 361W / 401W - 3000-4000 Lumen, WXGA
g. All ceiling projectors are to be securely mounted using UCD standard mounting hardware. Suspended ceiling tile-bridge mounts are acceptable for mounting projectors of less than 35 pounds. All tile bridge mounts must be securely tied to the ceiling structure. All mounting points included with the ceiling tile bridge must be secured. All projectors should be mechanically mounted to be center aligned with the projection screen. Mechanical, horizontal and vertical lens shift may be used to optimize the image. Digital keystone and pixel correction options are not acceptable options to overcome mechanical mounting alignment errors. Acceptable projector mounting hardware models include:

1) Chief Manufacturing – RPMA Projector Mount Bracket
2) Chief Manufacturing – CMS Series Mounting Hardware

All ceiling projector accessories and equipment, such as HDBaseT receivers, video baluns, audio amplifiers, power supplies, etc. must be mounted and secured in an accessible above ceiling plenum enclosure. Visible below ceiling connections to the projector must be cleanly installed, without AV devices mounted to the top of the projector, or to the projector mounting pole, etc. Duplex power and A/B data jacks described above, shall be coordinated and installed along with the plenum ceiling enclosure and required AV devices. The plenum ceiling enclosure shall be sized appropriately for the project.

Acceptable ceiling projector plenum enclosure models include:

3) Chief Manufacturing – CMA-470 / 471 / 472
4) Chief Manufacturing – CMS-491P2 / CMS492CP2
5) FSR – CB-12 / 22 / 224

All ceiling projectors shall be locked for security from theft. A key-locking, anti-theft alarm shall be professionally installed at each ceiling projector location. All alarm keys must be coordinated with Technology Support Services for uniformity and ease of service. All alarm keys shall be labeled and delivered to Technology Support Services at the conclusion of a project or major project phase.

Acceptable security alarm models include:

3) Secure-It – Sonic Shock Alarm 5 (Key # By Campus/Area)

h. Smaller conference rooms may include a direct-view television monitor in lieu of, or in addition to, a video projection system depending on the size dimensions and viewing requirements for the audience. All direct-view televisions shall be widescreen 16:9, 16:10, or 15:10 aspect ratio with a minimum 1080p native video resolution. Infrastructure for this location includes an un-switched, duplex power receptacle to be located inside a recessed AV enclosure directly behind the television location at 72” AFF to box center. A double-gang, low voltage electrical box with (1) 1.25” EMT conduit shall extend from the recessed AV box to above ceiling in an accessible location. A duplex receptacle and LAN / Telco “A/B” jack, shall be installed inside each recessed wall box. See TV wall box specifications, below. Acceptable television models include, but are not limited to:

1) Sharp - Aquos LC Series Televisions
2) Samsung – UN Series

i. All direct-view television displays are to be securely wall-mounted using The University standard mounting hardware. Television mounts must be secured to metal wall-studs not more than 16” from center to center with Hilti ¼” HTB Hollow Wall Anchors. All supplied hardware mounting points must be securely anchored to studs. Wall backing may be required as necessary under direction from Technology Support Services. Ceiling mount installation of direct-view displays is not preferred, although it may be required in unique situations as
necessary, under direction from Technology Support Services. Acceptable television mount
models include:

1) Chief Manufacturing – LTM, XTM Fusion Series Tilt Wall Mounts
2) Chief Manufacturing – MWR Series Swing-Arm Wall Mounts

All classroom television locations must include a deep, recessed, wall enclosure for electrical
infrastructure, data infrastructure, and AV devices. The recessed wall enclosure should be
adequately sized for the project. Acceptable wall recessed TV boxes include:

3) Chief Manufacturing – PAC-525 / 526
4) FSR – PWB-100 / 200 / 250 / 450

j. Sound reinforcement systems shall be built into conference rooms as required. Ceiling
microphones are typically utilized for small conference rooms with videoconference capability.
A pair of surface mount speakers shall be installed on the front wall or ceiling of each
conference room – facing the audience. Wall mounted speakers shall require a single-gang
low-voltage electrical box mounted directly behind the speaker location at 96” AFF with (1)
.75” EMT conduit extending to above ceiling in an accessible location. Depending on the size
of the conference room, additional distributed 70V ceiling speakers may be employed for
adequate sound coverage. Acceptable surface mount speaker models include:

1) JBL – Control Contractor Series Surface Mount Speaker
2) Tannoy – I Series Surface Mount Speaker
3) Tannoy – DI Series Surface Mount Speaker

k. Each conference room shall have a central audiovisual equipment rack location within. Smaller
conference room designs may locate equipment within a multimedia podium/lectern/credenza.
Larger systems may require an external wall-mount or floor-standing equipment rack. All
audiovisual equipment rack enclosures and/or closets shall be properly ventilated to maintain
the equipment at a suitable operating temperature. All AV rack locations shall include a
dedicated 20A duplex receptacle with no shared ground or neutral electrical wiring. All AV
equipment rack locations shall at minimum include an 8” x 8” screw cover (Hoffman Type)
pull box with (3) 1.25” EMT conduits extending to above ceiling in an accessible location. The
rack pull box shall be located adjacent to a dedicated 20A duplex receptacle and A/B data jack.
Mounting heights for wall rack electrical/pull boxes shall be 50” AFF. Mounting heights for
floor-standing equipment racks shall be standard receptacle height. Acceptable equipment rack
models include, but are not limited to:

1) Middle Atlantic – WRK Series Floor Standing Equipment Rack
2) Middle Atlantic – ERK Series Floor Standing Equipment Rack
3) Middle Atlantic – DWR Series Sectional Wall Mount Equipment Rack
4) Middle Atlantic – EWR Series Sectional Wall Mount Equipment Rack
5) Middle Atlantic – WRS Series Low Profile Equipment Rack

l. Each conference room that requires a podium will include an audiovisual floor box, which
shall be located directly underneath the podium location. Each conference room that includes
a central conference table will include one or more floor boxes located directly under the
conference table location. The audiovisual floor box will include knockouts and conduit
pathways for dedicated network “A/B”, audio / video cabling, and AC power cabling. A similar
layout would be used for other floor box locations as required within the conference room.
Acceptable audiovisual floor box models include:

1) Wiremold / Legrand - Evolution 6AT / 8AT Series Poke-Through Floor Devices
2) Wiremold / Legrand – RFB4 On Grade Floor Boxes
3) FSR – FL Series Concrete Pour In / Raised Access Boxes
m. Each conference room may include one or more pan/tilt/zoom camera locations for the purposes of video capture and/or videoconference integration. A pan/tilt/zoom camera shall typically be located on the front wall of the conference room with a clear view of the seated audience. The front, “audience view” camera shall typically be located in close proximity to the far-site “people” display – for optimal eye contact with the far audience. A secondary, “presenter view” camera may be utilized for additional conferencing capability. The secondary camera shall typically be located on the back wall or ceiling with an unobstructed view of the presenter. Infrastructure for each of these locations includes a double-gang, low voltage electrical box mounted at 72” AFF with (1) 1.25” EMT conduit extending to above ceiling in an accessible location. A duplex receptacle shall be installed directly adjacent to each camera location at 72” AFF.

n. Conference room lighting zones should be arranged to be dimmable and/or on/off controllable from the front of the room to the rear of the room. Specifically, the first row of conference room lighting shall be on a separate lighting zone so that excessive light does not degrade the quality of the video display systems typically located on the front wall of the conference room. Any pendant lighting and/or suspended lighting fixtures must not interfere with the projection system, which is typically centered with the room center. Light switches, dimmer controls, etc. shall typically be mounted at standard switch height in close proximity behind the presenters desk/podium, and shall be directly adjacent to the low voltage screen control switch and system control panel.

6. Control/Monitoring Rooms:

a. For remote or building-wide, audio/video monitoring, audio/video recording, audio/video routing, and/or system control capability to be realized, a centralized building audiovisual control/monitoring room may be required. Control/monitoring room requirements will typically be identified per project under the direction of CU Denver Office of Information Technology – Technology Support Services. The control/monitoring room shall typically be located on the first floor of the building within an acceptable distance of building IDF and/or MDF closets. The control/monitoring room shall be adequately cooled and ventilated to keep audiovisual equipment at a safe operating temperature. The control room will typically have a single array of large (44RU) audiovisual equipment racks containing the majority of the necessary routing, switching, and etc. equipment. Additional recording equipment, LCD monitors, etc. may be located in smaller (14RU) audiovisual equipment racks around the control room at various monitoring stations to accommodate the recording/monitoring capacity required. A heavy-duty counter surface will be installed on at least one wall of the control room for placement of audiovisual control/monitoring equipment.

b. Each control monitoring room shall include multiple LAN / Telco “A / B” jacks distributed around the room per campus IT standard. These network lines must be installed by or under the direction and control of CU Denver Office of Information Technology. In most cases there shall be located directly adjacent to this “A/B” jack, a duplex power receptacle and audiovisual input plate. Infrastructure for this location shall be a single-gang, low voltage electrical box mounted at standard receptacle height, with (1) .75” EMT conduit extending to an accessible ceiling location.

c. The control/monitoring room requires substantial EMT conduit infrastructure for various audiovisual equipment locations. A deep, screw cover (Hoffman Type) pull box “collection box” of at least 4’ in length shall be installed above the ceiling in the control/monitoring room with a minimum of (6) 2.00” EMT conduits connected directly to a nearby large capacity cable tray. Additional above ceiling pull boxes may be used for larger systems as required. All audiovisual infrastructure shall connect via the above ceiling collection box to various locations within the room.

d. The control/monitoring room will have audiovisual input/output plates distributed above the equipment counter surface for connection of audio / video monitoring, recording, and source
equipment. The input plate will typically be installed adjacent to a LAN / Telco jack and duplex receptacle. Each input plate location shall be a triple-gang low-voltage electrical box mounted at standard receptacle height, with (3) 1.25” EMT conduit connection to the above ceiling collection box. Active (powered) input plates such as Crestron DM-TX-200-C-2G are not acceptable for wall / floor input plate applications. A passive input plate should be used with an active transmitter mounted above the ceiling or in nearby junction box if required. Acceptable input plate/panel models include:

1) Liberty/PanelCrafters – Standard and Custom Fabricated
2) BTX Technologies, Inc. – Standard and Custom Fabricated
3) Extron – AAP/MAAP

e. The control/monitoring room will have audiovisual input/output plates distributed below the equipment counter surface for connection of audio / video monitoring, recording, and source equipment. The input plate will typically be installed adjacent to a LAN / Telco jack and duplex receptacle. Each input plate location shall be a triple-gang low-voltage electrical box mounted at standard receptacle height, with (3) 1.25” EMT conduit connection to the above ceiling collection box. Acceptable input plate/panel models include:

1) Liberty/PanelCrafters – Standard and Custom Fabricated
2) BTX Technologies, Inc. – Standard and Custom Fabricated
3) Extron – AAP/MAAP

f. The control/monitoring room may have several audiovisual equipment racks location within, depending on the project scope. All audiovisual equipment rack enclosures and/or closets shall be properly ventilated to maintain the equipment at a suitable operating temperature. All AV rack locations shall include a dedicated 20A quad receptacle with no shared ground or neutral electrical wiring. All AV equipment rack locations shall at minimum include a 12” x 12” screw cover (Hoffman Type) pull box mounted flush in wall with (6) 1.25” EMT conduit connection to above ceiling collection box. The rack pull box shall typically be located adjacent to a dedicated 20A quad receptacle and A/B data jack. All equipment rack locations should include proper grounding nearby via ground spike and/or ground bus system. Mounting heights for floor-standing equipment racks shall be standard receptacle height. Acceptable equipment rack models include, but are not limited to:

1) Middle Atlantic – WRK Series Floor Standing Equipment Rack
2) Middle Atlantic – ERK Series Floor Standing Equipment Rack

7. Digital Signage:

a. Digital signage hardware / software information systems may be used to offer CU Denver classroom scheduling, current events, etc. information to faculty, staff and students. Typical signage locations include high traffic, high visibility areas such as reception areas, elevator lobbies, foyers, and corridors. A typical signage location shall include a wall mounted LCD television with a built in, or associated signage player. The signage player shall accept signage content information via the building network. All signage screens are typically passive, non-interactive models. Interactive kiosk displays may be required for special applications under the direction of CU Denver Office of Information Technology – Technology Support Services.

b. Each digital signage location shall include behind the television monitor, a recessed AV enclosure, with a LAN / Telco “A / B” jack installed inside the enclosure per campus IT standard. These network lines must be installed by or under the direction and control of Office of Information Technology. A duplex power receptacle shall also be mounted inside the recessed AV enclosure. Mount recessed AV enclosure at standard 55” AFF to device center, with (1) .75” EMT conduit, and (1) 1.25” EMT conduit extending to an accessible above ceiling location.
c. All direct-view televisions shall be widescreen 16:9, 16:10, or 15:10 aspect ratio with a minimum 1080p native video resolution. Infrastructure for this location includes an unswitched, recessed AV enclosure, to be located in the wall directly behind the television location at 55” AFF to device center. (1) 1.25” EMT conduit will extend from the recessed AV enclosure to above ceiling in an accessible location. (1) .75” EMT conduit shall also be provided and installed to extend from the recessed AV enclosure to above ceiling in accessible location for the LAN / Telco “A/B” jacks. See TV wall box specifications below. Acceptable television models include, but are not limited to:

1) Sharp - Aquos LC Series Televisions  
2) Samsung – UN Series

d. All direct-view television displays are to be securely wall-mounted using University standard mounting hardware. Television mounts must be secured to metal wall-studs not more than 16” from center to center with Hilti ¼” HTB Hollow Wall Anchors. All supplied hardware mounting points must be securely anchored to studs. Wall backing may be required as necessary under direction from Technology Support Services. Ceiling mount installation of direct-view displays is not preferred, although it may be required in unique situations as necessary, under direction from Technology Support Services. In all cases, the Department of Justice’s 2010 ADA Standards must be employed. Particular attention shall be given to coordinate and install digital sign and kiosk locations that are acceptable under the ADA guidelines for “Protruding Objects” (DOJ ADA 307.1) Acceptable television mount models include:

1) Chief Manufacturing – Thinstall - TS525TU, LSTU, LTTU, MSTU, MTTU

All digital signage television locations must include a deep, recessed, wall enclosure for electrical infrastructure, data infrastructure, and AV devices. The recessed wall enclosure should be adequately sized for the project. Acceptable wall recessed TV boxes include:

1) Chief Manufacturing – PAC-525 / 526  
2) FSR – PWB-100 / 200 / 250 / 450
PART 4 - ILLUSTRATIONS

1. Example Lectern Configurations – Small Podium (Illustration Ex. 1)
2. Example Lectern Configurations – Medium Podium (Illustration Ex. 2)
Part 2 Continued
3. Example Lectern Configurations – Large Multimedia Podium (Illustration Ex. 3)
SECTION 27 51 00 - DISTRIBUTED AUDIO-VIDEO COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

1.2 SUMMARY

A. Section 27 51 00 describes the codes, standards, specifications, recommendations, and practices required for Emergency Notification LED Boards placement and installation at the The University of Colorado Denver | Anschutz Medical Campus (the University). Section 27 51 00 applies to all university campuses.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Product Data for the following products:
   1. LED Board.

C. Installation Instructions: Manufacturer’s written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer’s Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.

F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.

H. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.’s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.
I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, "Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps."

1.5 DELIVERY, STORAGE, AND HANDLING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.10 DEFINITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. LED Board
   1. Inova – OnAlert
   2. Inova - Lightlink

PART 3 - EXECUTION

3.1 LED EMERGENCY MESSAGING BOARD INSTALLATION REQUIREMENTS
A. LED Emergency Messaging Board Placement.
   1. LED Emergency Messaging Board are placed in common areas and areas where large groups congregate including but not limited to elevator lobbies, large (75+ seat) classrooms waiting rooms and all public areas that could anticipate containing 10 or more visitors.

B. Installation Practice.
   1. IT conduits and back-boxes. IT Services requires one Trade Size 1, 1-inch conduit to support data connectivity to the LED Board. Back-box shall be 2-gang deep type with single gang mud ring. Back-Box should typically be provided between 8-10ft above finished floor, coordinate final mounting location and height with the University.

C. Power Requirements
   1. LED boards are to be Power over Ethernet (PoE).

D. Communications Media.
1. All LED Board communications media is provided by the IT Services department and is managed under a separate contract.

END OF SECTION 27 51 00
SECTION 27 53 19 – DISTRIBUTED ANTENNA SYSTEM (DAS)

1.1 REFERENCES

A. Applicable Codes, Standards, and Specifications.
1. The following table of codes, standards, specifications, recommendations, and methods and procedures are applicable to the provisioning of a DAS for the University of Colorado Denver | Anschutz Medical Campus, Office of Information Technology (OIT). The latest editions are incorporated by reference.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electric Code (NEC)</td>
</tr>
<tr>
<td>IEEE C2</td>
<td>National Electric Safety Code (NESC)</td>
</tr>
<tr>
<td>IEC 62037</td>
<td>RF Connectors, Connector Cable Assemblies and Cables – Intermodulation Level Measurement</td>
</tr>
<tr>
<td>OSHA</td>
<td>Standard 29 CFR 1910.268</td>
</tr>
</tbody>
</table>

2. All work, including, but not limited to: cabling, pathways, support structures, equipment placement and installation, workmanship, maintenance, and testing shall comply with the latest editions of the NEC, NESC, FCC, all applicable rules and regulations, manufacturer’s instructions, and University of Colorado Denver | Anschutz Medical Campus OIT standards and related methods and procedures.

3. OIT shall be regularly consulted with during DAS project design and deployment through the assigned University of Colorado Denver | Anschutz Medical Campus project manager.

1.2 ABBREVIATIONS AND ACRONYMS AND DEFINITIONS

A. Abbreviations and Acronyms
1. AHJ: Authority Having Jurisdiction
2. ATP: Acceptance Test Plan
3. BICSI: Building Industry Consulting Service International
4. BDA: Bi-Directional Amplifier
5. BOM: Bill-of-Materials
6. BTS: Base Transceiver Station
7. CDMA: Code Division Multiple Access
8. DAS: Distributed Antenna System
9. FCC: Federal Communications Commission
10. iDEN: Integrated Digital Enhanced Network
11. LTE: Long Term Evolution
12. NEC: National Electrical Code
14. OTDR: Optical Time-Domain Reflectometer
15. PIM: Passive Intermodulation
16. PTT: Push-to-Talk
17. RF: Radio Frequency
18. RSL: Received Signal Level
19. RSSI: Received Signal Strength Indicator
20. SNIR: Signal-to-Noise Interference Ratio
22. SOW: Statement of Work
23. TR: Telecommunications Room
24. WSP: Wireless Service Provider

B. Definitions
1. Acceptance: expressed approval by the university
2. Active: DAS components that require AC/DC power for operation
3. Carrier Approval: expressed approval to interconnect to the WSP macro network
4. Channel: a path for RF transmission between two points
5. Component: a main system element of the DAS
6. Contractor: the prime contractor bidding the project
7. dBc: power ratio in decibels of a signal compared to the carrier level
8. dBm: power ratio in decibels of the measured power referenced to one milliwatt
9. OIT: the university DAS owning agent or customer
10. Passive: DAS components that do not require AC/DC power for operation
11. PIM: passive intermodulation distortion resulting from high frequency mixing in passive components such as connectors

1.3 QUALITY ASSURANCE

A. Consult with the OIT department for the following:
   1. Acceptability for substitutions for specific components.
   2. Guidance in the application of a standard or specification in a design or deployment situation.
   3. Approval for deviation from standards, specifications, or industry-standard methods and procedures.

B. Qualifications.
   1. The contractor and subcontractors shall have a minimum of 3-year’s experience performing work of a similar nature.
   2. The installation contractor shall have installed similar systems in at least three locations in the previous 2-years.
   3. All DAS equipment shall be furnished and installed by an authorized factory distributor. The installer shall have proven experience in the design, installation, and commissioning of the specified DAS solution.

C. Certifications.
   1. Contractor or subcontractor shall provide manufacturer certification that the contractor or subcontractor personnel have been trained on the active and passive DAS components being installed.

D. Warranty.
   1. Warrant all equipment and materials for 1-year from date of final OIT acceptance.
   2. Labor and material shall be covered by the warranty.
   3. Contractor shall do all registrations and provide proof of purchases required to activate any manufacturer’s warranty.

1.4 DAS DESCRIPTION

A. This section includes technical and performance requirements for designing and deploying a DAS capable of supporting PTT public safety radios, cellular carriers, and other RF technologies. These entities are referred to as Wireless Service Providers (WSP). This standard does not list, describe, or delineate every active component, passive component, materials, or necessary means to complete the DAS project. The DAS contractor shall be responsible for determining and providing all elements necessary to create an operational, scalable, and maintainable system for use by OIT. Elements of a DAS include, but are not limited to:
   1. Design
   2. Project management
   3. WSP coordination
4. Customer coordination with OIT
5. Coordination with other trades
6. Furnishing and installing all active DAS components
7. Furnishing and installing all passive DAS components, including cabling and fiber optics
8. DAS configuration, programming, adjustment, and tuning
9. Coordination and management of WSP RF interconnections to the DAS
10. DAS labeling to campus standards
11. Documentation and DAS training
12. System acceptance testing
13. Final system turnover to OIT

B. The fielded, operational DAS will support these WSP, at the incoming RF specified by the WSPs:
   1. Convenience DAS that supports:
      a. Verizon
      b. Sprint
      c. T-Mobile
      d. AT&T
   2. Public Safety DAS (possibly a stand-alone system as determined by the AHJ)
      a. The public safety DAS should be the same equipment vendor as the convenience DAS supplier

C. Support of 4th generation LTE WSP solutions is required. Bolt-on support for 5G and other emerging standards is required.

D. The contractor shall provide all DAS and WSP coordination to include:
   1. Coordination meetings with owner, general contractor, and the design team.
   2. Assist the university with WSP negotiations.
   3. Obtain WSP interconnect interest.
   4. Acquire WSP interconnect permissions.
   5. Coordinate layout and installation of DAS pathways, cabling, conduits, and antenna placement with the design team.
   6. Coordinate WSP power and cooling requirements with the design team.
   7. Verify carrier space requirements.
   8. Coordinate WSP deployment schedule and commissioning.
   9. Officially notifying WSP prior to system going on-air.

E. The contractor supplied DAS will conform to all codes, ordinances, and supplemental requirements of the AHJ; including building a separate public safety DAS, if required.

F. The DAS shall include a head-end that is able to service the University of Colorado Denver campus footprint, as defined by OIT. The head-end shall be collocated with the WSP systems necessary to support the systems and services described.
   1. The contractor shall provide head-end physical space requirements to the design team.
      For design planning purposes, initially assume a head-end room sized to 14’ x 16’, minimum.
   2. The contractor shall provide head-end power requirements to the design team.
      a. Assume a 200-amp dedicated head-end power panel for initial design purposes.
   3. The contractor shall provide head-end cooling requirements to the design team.
      For design planning purposes, initially assume 6 tons of cooling for the head-end, minimum.
   4. The contractor shall provide head-end telecommunications requirements to the design team.

G. The DAS shall have all active component remote units located in OIT Telecommunications Rooms (TR).
   1. OIT will specify where active and passive DAS components may be installed in the TR.
      a. The contractor shall provide DAS TR space requirements to the design team.
      b. The contractor shall provide DAS TR power requirements to the design team.
      c. The contractor shall provide DAS TR cooling requirements to the design team.
      d. The contractor shall provide DAS TR cabling requirements to the design team.

H. Subject to compliance with the UC Denver | Anschutz Medical Campus DAS requirements, the contractor shall provide a complete and functioning Solid Technologies DAS.
I. DAS performance.
   1. Long Term Evolution (LTE) carrier signal strength shall exceed -70 dBm or meet the WSP’s signal strength requirements with 95% coverage, including basements, elevators and stairwells, but without penetration of the elevator shaft or stairwell.
   2. The DAS shall distribute cellular carrier signal strength so that it exceeds -75 dBm or meet the WSP’s signal strength requirements with 95% coverage including basements, elevators and stairwells, but without penetration of the elevator shaft or stairwell.
   3. Public Safety signal strength shall exceed -95 dBm with 95% coverage or as stipulated by the AHJ. The AHJ may stipulate which areas need specific coverage.

J. DAS Coverage. The DAS shall provide 95% coverage throughout the building. A perimeter based design is preferred. The coverage areas include, but are not limited to the following.
   1. Public spaces
   2. All floors including corridors and lobbies
   3. Basement
   4. Stairwells as best enabled without penetrating into the stairwell
   5. Elevators as best enabled without penetrating into the elevator shaft
   6. Restrooms as best enabled without penetrating into the restroom
   7. Break rooms
   8. Telecommunications Rooms and Mechanical Rooms

K. The DAS shall have the capability for separate control over each WSP to permit the adjustment and control of power levels without impacting other WSPs.

L. The DAS shall support multiple WSPs in a modular architecture so that other WSPs can be added or removed without requiring new infrastructure.
   1. This modular architecture shall not require adding or replacing passive components such as cabling or antennas when services are added or deleted.
   2. The modular architecture will accept WSP changes without significant head-end modifications.

M. The DAS shall be managed by a system that allows monitoring, alarming, and alerting of active components. The DAS management system will perform fault isolation and allow system configuration and control.
   1. The DAS will integrate into the university’s Ethernet network via the SNMP protocol.

N. The DAS components shall be rated for the environments in which they are installed.

O. The DAS components shall be labeled per the OIT standards.
   1. Submit labeling samples to OIT for approval prior to placement to ensure color, format, and media are suitable to the task.
      a. Permanent, machine-printed labels are required, as specified by OIT.
      b. Cable labels shall be wrap-around and self-laminating to provide permanent marking.

P. The contractor shall provide training for the OIT maintainer.
   1. Provide final copies of DAS active component manuals to OIT prior to scheduling system demonstration and instruction.
      a. Provide two instruction sessions describing and demonstrating all maintenance and operational aspects of the DAS.
      b. Training shall be conducted by a vendor or supplier’s representative trainer who is thoroughly familiar with all aspects of the DAS.

Q. The contractor shall perform system commissioning, tuning, acceptance testing, and sign-off activities.
   1. Submit an Acceptance Test Plan (ATP) that describes the systematic process for DAS validation and commissioning.
   2. The contractor shall sweep-test the entire system with a spectrum analyzer from the head-end to the last component in each distribution leg.
      a. Test all cable segments at frequency sweeps around 160, 460, 700, 840, 930, and 1925 MHz. The sweep bandwidth should be reflective of common spectrum bands in that frequency range.
      1. The return loss at any connector shall be greater than 20 dB.
b. Notify OIT 2-weeks in advance of sweep testing so the university can witness the testing procedures and results.
c. Submit test results for all cable tests to the design team 2-weeks prior to punch list review.

3. Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
   a. Visually inspect and clean all connectors before mating them.
   b. Torque all connections to 16 to 18 ft-lbs (23-24 Nm) or to the manufacturer’s specification.
   c. Premanufactured passive assemblies are preferred over field termination to help reduce PIM.

1.5 SUBMITTALS

A. Submit a Bill-of-Materials (BOM) containing all active and passive components.
B. Submit manufacturer cut sheets for the following components:
   1. Passive component cut sheets.
   2. Active component cut sheets.
C. Submit hardware and software manuals for all active components.
D. Submit shop drawings in hard copy and electronic format as specified by OIT
   1. Submit pictures of installation workmanship, showing locations of major active components such as BTSs, BDAs, donor antennas, and head-end racks.
   2. Submit pictures samples of typical passive component installations such as splitters, couplers, or ceiling antennas.
   3. Submit an RF link budget.
E. Provide an overlay of system components on floor plans.
   a. Submit as-builds showing final antenna locations, couplers, splitters, coaxial and fiber cable routing, active and passive component placement in each TR, and WSP connections.
   b. Provide predictive modeling coverage plans (signal strength) by floor and WSP for each frequency band.
F. Submit heat maps showing DAS coverage and coverage density by floor.
   a. Provide as-builds showing final antenna locations, couplers, splitters, coaxial and fiber cable routing, active and passive component placement in each TR, and WSP connections.
G. Provide as-builds showing final antenna locations, couplers, splitters, coaxial and fiber cable routing, active and passive component placement in each TR, and WSP connections.
H. Submit overhead drawings in hard copy and electronic format as specified by OIT
   1. Submit pictures of installation workmanship, showing locations of major active components such as BTSs, BDAs, donor antennas, and head-end racks.
   2. Submit pictures samples of typical passive component installations such as splitters, couplers, or ceiling antennas.
   3. Submit an RF link budget.
I. Provide an overlay of system components on floor plans.
   a. Submit as-builds showing final antenna locations, couplers, splitters, coaxial and fiber cable routing, active and passive component placement in each TR, and WSP connections.
   b. Provide predictive modeling coverage plans (signal strength) by floor and WSP for each frequency band.
J. Submit heat maps showing DAS coverage and coverage density by floor.
K. Submit WSP contact information in hard copy and electronic format as specified by OIT.
1. Provide technical points of contact for each WSP to include name, WSP position, telephone number, and email address.

L. Submit a maintenance proposal for time and material support. Assume a one business day response window for the proposal.

END OF SECTION 27 53 19
PART 1 - GENERAL.

1.1 REFERENCES

A. General provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections.

B. Architectural, Electrical, and Technology Drawings. Other systems drawings may apply. Division 26 Basic Electrical Materials and Methods sections apply to work of this section.

C. Applicable Codes, Standards, and Specifications.
   1. The following table of codes, standards, specifications, recommendations, and methods and procedures are applicable to the provisioning of a data center (DC) for the University of Colorado (CU) Denver | Anschutz Medical Campus (AMC), Office of Information Technology (OIT). The latest editions are incorporated by reference.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electric Code (NEC)</td>
</tr>
<tr>
<td>IEEE C2</td>
<td>National Electric Safety Code (NESC)</td>
</tr>
<tr>
<td>TIA 942</td>
<td>Telecommunications Infrastructure Standard for Data Centers</td>
</tr>
<tr>
<td>BICSI</td>
<td>Telecommunications Distribution Methods Manual; Customer-Owned Outside</td>
</tr>
<tr>
<td></td>
<td>Plant Design Manual; ANSI/BICSI 002, Data Center Design and Implementation</td>
</tr>
<tr>
<td></td>
<td>Best Practices</td>
</tr>
<tr>
<td>OSHA</td>
<td>Standard 29 CFR 1910.268</td>
</tr>
</tbody>
</table>

2. OIT shall be regularly consulted with during Anschutz Data Center (ADC) project design, construction, and commissioning through the assigned CU AMC Facilities Projects, project manager (PM).

3. A BICSI certified Registered Communications Distribution Designer (RCDD) and a Data Center Design Consultant (DCDC) are required for this data center project.

4. OIT will assign a PM for the information technology (IT) portion of the ADC project. Contact Rob Lee (Rob.Lee@UCDenver.edu, 303.724.0443) TNI program director or Tasha Carlson (Tasha.Carlson@UCDenver.edu, 303.724.0402) Construction Services manager for OIT PM support.

5. OIT will also assign members of its Data Center directorate to participate in the project as Data Center SMEs. The OIT Data Center program director is Frank Whispell (Frank.Whispell@UCDenver.edu, 303.724.0300). The OIT Data Center manager is Steve Stelzer (Steve.Stelzer@UCDenver.edu, 303.724.0498).

6. OIT operates three existing CU data centers with these characteristics:
   a. North Classroom Data Center: 34 racks, ~1700 ft².
   b. Communications Center: 26 racks, ~1720 ft².
   c. Communications Center Annex: 18 racks, ~1000 ft².
   d. 78 total racks in ~4420 ft².

7. OIT SPLICE goals for the ADC:
   a. Service: the ADC shall materially enhance the voice, networking, computing, storage, and security services provided by OIT.
   b. Professional: the ADC shall be designed and constructed to reflect professional OIT DC administration and operations.
   c. Leadership: the ADC shall reflect CU Denver | AMC leadership in the data center field.
   d. Innovation: the ADC shall be designed around DC innovations and materially enhance innovation in telephony, networking, security, computing, and storage.
e. Community: provide a community space for the telephony, networking, security, computing, and storage teams to create OIT services in a collegial environment.

f. Excellence: the ADC shall be designed to support OIT excellence in providing IT services.

1.2 ABBREVIATIONS AND ACRONYMS AND DEFINITIONS

A. Abbreviations and Acronyms.

1. ADC: Anschutz Data Center
2. AHEC: Auraria Higher Education Center
3. AHJ: Authority Having Jurisdiction
4. AMC: Anschutz Medical Campus
5. ANSI: American National Standards Institute
6. AOC: ADC Operations Center
7. AP: Access Point
8. APC: American Power Conversion Corporation
9. ASF: Assignable Square Footage
10. ATP: Acceptance Test Plan
11. BAS: Building Automation Systems
12. BICSI: Building Industry Consulting Service International
13. BOM: Bill-of-Materials
14. BTU: British Thermal Unit
15. CAD 3D: Computer-Aided Design three dimensional
16. CCPM: Colorado Center for Personalized Medicine
17. CCTV: Closed Circuit Television
18. CDAS: Campus Distributed Antenna System
19. CI: Computing Infrastructure
20. CRAC: Computer Room Air Conditioner
21. CRM: Customer Relationship Management
22. CU: University of Colorado
23. CUP: Central Utility Plant
24. DAS: Distributed Antenna System
25. DC: Data Center
26. DCDC: Data Center Design Consultant
27. DCiE: Data Center Infrastructure Efficiency
28. DCIM: Data Center Infrastructure Management
29. DX: Direct Expansion
30. EIA: Electronic Industries Alliance
31. EMI: Electromagnetic Interference
32. EPO: Emergency Power Off
33. ERP: Enterprise Resource Planning
34. ESD: Electrostatic Discharge
35. FCC: Federal Communications Commission
36. FCU: Fan Coil Unit
37. FM-200: Factory Mutual 200 fire suppressant agent
38. ft²: square foot
39. HPC: High Performance Computing
40. HVAC: Heating, Ventilation, Air Conditioning
41. IEEE: Institute of Electrical and Electronics Engineers
42. IPS: Intrusion Protection System
43. IT: Information Technology
44. kW/hr: kilowatt per hour
45. lbs/ft²: pounds per square foot
46. N: Need
47. NEC: National Electric Code
B. Definitions.

1. **Computer Room**: area in a data center containing the equipment racks, but not the support utilities and other support services. Computer rooms are unstaffed areas. See illustration.

2. **Data Center**: area containing the computer room and support utilities and other needed services. Smaller data centers may have the computer room and support utilities embedded in one room called the data center. Staff offices may be housed in the data center.

3. **OIT**: the university unit that creates, manages, and operates centralized IT at CU Denver | AMC.

4. **Pod**: a collection of racks, PDUs, and CRACs that form a self-contained unit. Typically the inside of the pod is the hot aisle, while the exterior of the pod creates the cold aisles.
1.3 SUMMARY

A. Systems Performance Requirements.
1. Design, build, and commission a TIA-942, Tier 3 mission critical data center. The data center shall provide computer room space and supporting integrated infrastructure such as racks and pods, cooling, power, fire, and security for converged low voltage systems such as telephony, routing, switching, data storage, computing, servers, High Performance Computing (HPC), security, visualization, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), closed circuit TV (CCTV), community antenna TV, Building Automation Systems (BAS), Distributed Antenna System (DAS), overhead-paging systems, and other low voltage systems. Coordinate ADC design criteria and construction with the OIT PM and DC SME.
2. The data center must be reliable, available, and maintainable. It must be secure, efficient, effective, and scalable.
3. The data center shall provide a safe working environment for OIT personnel.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 National Electrical Code.
B. Manufacturers: Firms regularly engaged in manufacture of data center components and infrastructure, whose products have been in satisfactory use in similar service for not less than five years.
C. Installer’s Qualifications: Firms with at least five years of successful installation experience on similar data center projects.
D. NEC Compliance: Comply with NEC as applicable to the design, construction, and installation of data center systems and infrastructure.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.6 SEQUENCING AND SCHEDULING

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.7 PROJECT SITE CONDITIONS

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.8 WARRANTY

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.9 SPECIFICATION RESPONSE

A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

1.10 DEFINITIONS
A. Refer to Section 27 05 00 for requirements that shall be fulfilled as part of this specification section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers for UPS, CRACs and PDUs: subject to requirements and OIT approval, provide products by the following:
   1. Schneider (APC).
   2. Emerson (Liebert).

B. OIT has extensive experience with Schneider and Emerson products and they are our preferred vendors. The APC product line has a much wider distribution on the CU Denver | AMC campuses.

PART 3 - SUBMITTALS

3.1 SUBMIT THE FOLLOWING

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Installation Instructions: Manufacturer’s written installation instructions for all ADC products.

C. Submit a combination ADC layout plan for coordination, providing section views of areas as required, in accordance with the requirements of Section 26 05 00.
   1. Provide as-built, scale floor plans showing all equipment.
   2. Label all equipment shown on the drawings.

D. Submit to OIT the following ADC materials:
   1. Provide a Bill-of-Materials (BOM) containing all components.
   2. Product Data and cut sheets for the following products:
      a. CRAC.
      b. UPS.
      c. PDU.
      d. Racks and enclosures.
      e. Humidification systems.
      f. Fire detection and suppression systems.

E. Deliver hardware and software manuals for all components.

F. Submit shop drawings in hard copy and electronic format as specified by OIT.
   1. Submit pictures of installation workmanship.
   2. Submit pictures and sketches of electrical and chilled water pathways.

G. Acceptance Test Plan (ATP) in hard copy and electronic format as specified by OIT.
   1. Submit an ATP showing the viable operation of all components.
   2. Testing of the ADC physical infrastructure as a whole system, including the following:
      a. IT and physical infrastructure or IT loads simulation.
      b. Cooling system testing.
      c. Induced utility power interruption.
      d. Fire suppression system testing.
      e. System monitoring and alarming testing.
      f. EPO tests.
      g. System set points are verified.
3. Submit test results in hard copy and electronic format as specified by OIT.
4. Provide demonstration and training on operational components.

H. Submit appropriate warranty documents in hard copy.
1. Submit warranty for all manufactured components used in the ADC
2. Submit contractor’s system warranty.
3. Submit manufacturer’s extended warranty.

I. Provide technical POCs for each ADC system or major subsystem to include name, company, street address, position, telephone number, and email address.

PART 4 - DATA CENTER DESIGN CRITERIA

4.1 DATA CENTER SITE

A. The Anschutz Data Center (ADC) will be placed on the CU Anschutz Medical Campus (AMC) located in Aurora, CO.
1. The working name of the building housing the ADC is the CCPM (Colorado Center for Personalized Medicine) Building.
2. The building housing the ADC shall be a shared multistory structure, not dedicated as a data center facility.
3. The CCPM Building may approach 500,000 ft² on 12 floors.
4. Two locations, sites X1 and X2 as shown in red in the sketch, are under consideration at AMC for the CCPM Building and the ADC placement. The university will select the construction site prior to design.
5. The CCPM Building will probably house academic, research, clinical, and administrative users of IT.

B. The ADC should not be placed in the CCPM building’s basement or on the first floor. The building’s top floor is also inappropriate due to potential water infiltration from roof leaks.
1. Avoid placing the ADC near or adjacent to:
   a. Building core areas (security concerns).
   b. Cafeterias (water infiltration issues).
   c. Breakrooms (water infiltration issues)
   d. Elevator control rooms (potential EMI).
   e. Loading docks (vibration effects).
   f. Trash compactors (vibration effects).
   g. Mechanical rooms (potential EMI).
   h. Electrical rooms (potential EMI).
   i. Restrooms (water infiltration issues).
   j. Wet labs (water infiltration issues).
2. Systems that support the data center may be placed in the ADC footprint, with OIT approval. All other systems shall be routed around the ADC.
3. All overhead and beneath floor infrastructure collisions should be presented in CAD 3D to the OIT PM for their review and routing approval.
C. ADC Size.
1. The ADC should be 5,200 assignable square feet (ASF), roughly 80 feet by 65 feet.
   a. The computer room shall be combined with the support utilities and services into one large data center footprint.
   b. The equipment in the computer room will probably be built in phases, where the capacity needed for the foreseeable future is created by adding just-in-time pods.
   c. The computer room should be designed to facilitate expansion via plug-in pods.
   d. A notional ADC floor layout is shown below.

2. Initial rack count planning.
   a. The university may elect to consolidate all existing decentralized AMC server rooms into the ADC because of the enhanced security, effectiveness, and efficiency of the ADC. If implemented, this consolidation may require up to 32 racks.
   b. OIT may elect to share racks with other state and higher education entities to foster better disaster recovery. This effort may require 6 racks.
   c. OIT’s initial 2-year build-out requirement may consume 16 racks.
   d. The initial design should allocate three pods of a minimum of 18 racks each to cover the above rack count estimates. The estimated maximum electrical and thermal loads for 54 initial racks are shown below.

<table>
<thead>
<tr>
<th>Rack Use</th>
<th>Estimated kW/rack</th>
<th>Initial Racks Needed</th>
<th>Total kW</th>
<th>Total BTU</th>
<th>Tons of Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecom</td>
<td>5</td>
<td>6</td>
<td>30</td>
<td>102,363</td>
<td>9</td>
</tr>
<tr>
<td>Server</td>
<td>12</td>
<td>42</td>
<td>504</td>
<td>1,719,698</td>
<td>144</td>
</tr>
<tr>
<td>HPC</td>
<td>25</td>
<td>6</td>
<td>150</td>
<td>511,815</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td><strong>54</strong></td>
<td><strong>684</strong></td>
<td><strong>2,333,876</strong></td>
<td></td>
<td><strong>196</strong></td>
</tr>
</tbody>
</table>

3. The final rack build-out in the ADC may entail over 100 racks in 5 pods. See maximum kW and BTU estimates below for the total ADC build-out.
4. Incorporate these auxiliary spaces (ranges from 1,044 to 1,104 ASF) into the ADC design. These auxiliary spaces are not in the ADC 5,200 ASF footprint:
   a. Office areas.
      1) Two data center offices are required that are sized 10 feet x 12 feet (240 ft²).
      2) Four open office landing zones are desired (80 ft² x 4 = 320 ft²).
   b. Secured (via university access card reader with PIN pad) ADC Operations Center, sized about 10 feet x 12 feet (120 ft²). If an audio-visual control room is collocated in the ADC Operations Center (AOC), the room should be increased in size to 12 feet x 15 feet (180 ft²).
   c. One conference room with integrated VTC support (~120 ft²).
   d. Secured (via university access card reader with PIN pad) supply and storage room (10 feet x 10 feet = 100 ft²).
   e. Secured (via university access card reader with PIN pad) shipping, receiving, and equipment staging area (12 feet x 12 feet = 144 ft²).
   f. This auxiliary space may be used for future ADC expansion.

4.2 DATA CENTER TIER

A. Provide a TIA 942, Telecommunications Infrastructure Standard for Data Centers, Tier 3, Concurrently Maintainable Data Center or as specified by OIT.
   1. Tier 3: a data center that has redundant components and multiple independent distribution paths serving the computer equipment in the computer room. Typically, only one distribution path serves the computer equipment at any time. The data center is concurrently maintainable which means that each component including the distribution path, can be removed, replaced, or serviced without disrupting the capabilities to the customer. The Tier 3 Concurrently Maintainable data center has protection against most physical events or outages.
   2. The Concurrently Maintainable data center should have an availability that approaches 99.982% which translate into 1.6 hours of unplanned outages per year. This tier provides 2N availability.
   3. TIA-942 Availability Percentages by tier are shown:

<table>
<thead>
<tr>
<th>Availability Percentage</th>
<th>Uptime (min/year)</th>
<th>Uptime (hours/year)</th>
<th>Downtime (min/year)</th>
<th>Downtime (hours/month)</th>
<th>Downtime (hours/month)</th>
<th>Downtime (hours/year)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>99.671</td>
<td>523,871</td>
<td>8,731</td>
<td>1,729</td>
<td>144</td>
<td>2.4</td>
<td>28.8</td>
<td>Tier 1, Basic Data Center, N</td>
</tr>
<tr>
<td>99.749</td>
<td>524,281</td>
<td>8,738</td>
<td>1,319</td>
<td>110</td>
<td>1.8</td>
<td>22.0</td>
<td>Tier 2, Redundant Components, N+1</td>
</tr>
<tr>
<td>99.982</td>
<td>525,505</td>
<td>8,758</td>
<td>95</td>
<td>7.9</td>
<td>0.13</td>
<td>1.6</td>
<td>Tier 3, Concurrently Maintainable, 2N</td>
</tr>
<tr>
<td>99.995</td>
<td>525,574</td>
<td>8,760</td>
<td>26</td>
<td>2.2</td>
<td>0.04</td>
<td>0.44</td>
<td>Tier 4, Fault tolerant, 2(N+1)</td>
</tr>
</tbody>
</table>

B. TEAM = T³E³A²M².
   1. TEAM is an acronym standing for Telecommunications, Electrical, Architectural, and Mechanical, the four quintessential operational elements of a DC.
   2. T³E³A²M² signifies that not all levels of the TEAM components can be commissioned at the Tier 3 level. The campus has architectural site constrains such as a proximity to running water, an Interstate nearby, a police station on campus, several hospitals collocated on campus, overhead airways, extensive on-campus research facilities, and other significant, potential site hazards.
3. The ADC’s Telecommunications, Electrical, and Mechanical systems should be designed and built to the Tier 3 standard.
4. Architectural systems should be built to Tier 3 if possible, but Tier 2 may be the highest tier that can be achieved, given the inherent campus constraints.

C. Criteria used for building a Tier 3 data center at AMC.
1. The university has a high dependence on IT.
2. There is a high cost associated with IT downtime.
3. The university is a large, multimillion dollar business.
4. The university possesses a Public Safety Answering Point (PSAP) or emergency 911 call center.
5. We have a highly recognized brand.
6. The university has a state-wide, country-wide, and world-wide Internet presence.
7. The university engages in four different higher education activities with widely varying IT requirements:
   a. Research.
   b. Administration.
   c. Clinical and healthcare.
   d. Education.
8. The university has 24x7x365 expectations for IT services.
9. The university supports three campuses (CU Denver at AHEC, AMC in Aurora, and CU South in Parker) and about 30 offsite business locations, many of the offsite locales are clinical in nature.
10. The university readily complies with a variety of governmental regulations that require we secure and safeguard our data resources.
11. The faculty, staff, and students have high expectations for the university's disaster recovery abilities.
12. OIT implemented a network-based VoIP telephone system; that phone system is critical to university business.
13. OIT has a relentless focus on uptime and enhanced customer service that can only be achieved with a Tier 3 data center.

D. It should be noted that availability level cannot be ensured by design specification alone. Most DC service interruptions result from human error, not mechanical failure. Therefore, thoughtful attention to skill development, hands-on training, knowledge-based certification, and a positive, nurturing work environment will help contribute to a high availability, zero-defect computing environment that OIT desires.

4.3 GENERAL DATA CENTER GUIDELINES

A. All successful operational aspects of the university computing environment will result from the reliability, availability, and maintainability (RAM) of the ADC. Redundancy, effectiveness, efficiency, and scalability (REES) are required for the long-term viability and success of the ADC. The RCDD/DCDC designer needs to incorporate these guidelines into their ADC design.

B. ADC Guidelines.
1. Floor loading: minimum 250 lbs/ft².
   a. This number includes battery weight loads.
   b. If the ADC exceeds 5,200 ft², consider 300 lbs/ft² minimum floor loading.
2. Raised Floor: none desired.
3. The ADC floor shall not be carpeted.
4. A minimum floor-to-floor clearance of 13 feet is desired.
5. Windows: placed so OIT can use the windows for ADC emergency cooling in the winter.
6. Place electrical pathways in the cold aisle pathway in the ceiling.
7. Place telecommunications pathways in the hot aisle pathway located in the ceiling.
8. Route chilled water pipelines from below the floor, if feasible.
9. Chilled water leak detection required.
10. The ADC shall not be located below lavatories, wet labs, washrooms, break rooms, or other areas where inadvertent water leakage may occur.
   a. The ADC shall have a drainage point for water removal.
      1) The ADC drainage piping shall have a shutoff ball or check valve to prevent backflow from entering the ADC through drain lines.
      2) A 12” diameter or larger drainage point is desired.
11. Avoid placing the ADC in areas of high EMI.
12. Ensure there is a freight elevator in the CCPM Building sized to meet the needs of the ADC.
13. The computer room shall not be a primary pathway to support areas.

C. Pods and racks.
1. Pods may support the following types of equipment:
   a. Telecommunications.
   b. Servers.
   c. HPC.
   d. Mixed telecommunications, server, and HPC equipment.
2. Racks shall comply with EIA-310-D standard to house EIA-310 compliant equipment.
   a. Each rack shall support a static weight load of up to 3,000 lbs.
   b. Rack depth shall be a minimum of 46 inches or as specified by OIT.
   c. Racks should be hinged for right or left operation.
   d. Racks shall possess numbered U positions.
   e. Racks shall have adjustable leveling feet.
   f. Racks shall have lockable doors and lockable side panels.
      1) With individually unique locksets with four master keys.
   g. Racks should be equipped with a university card access control system.
   h. Ground (earth) all rack enclosures.
3. Do not place more than 20 racks in row in any pod.
   a. Do not place more than 10 racks in a row if one end of the hot aisle is closed off and there is no secondary personnel exit in the pod.
4. Pods require redundant electrical feeds.
   a. Place redundant PDUs to support the pod.
   b. Attach the redundant PDUs to redundant UPSs.
   c. Each rack in a pod requires redundant metered power strips that connect to the redundant PDUs.
5. Label all pods and racks as specified by OIT.

D. The ADC doors shall be a minimum of 36” wide by 80” high. Due to the nature of the equipment located in the ADC, the ADC requires at least one oversized door (72” by 90” or larger) to allow oversized equipment to be moved in or out. All doors shall be self-closing. ADC doors shall open outward or be removable from the inside. ADC doors shall have a minimum of a 1-hour fire-rating or as stipulated by the AHJ.

E. The ADC requires lighting with a uniform intensity exceeding 50 foot-candles (500 lux) when measured 3 feet above the finished floor. Indirect lighting is not desired. Use white colored finish to enhance ADC lighting.
1. Connect ADC lighting fixtures to separate electrical circuits from those that accommodate the IT equipment in the room.
2. ADC lighting shall use high efficiency ballasts and lamps.
3. Lighting fixtures shall be aligned parallel to equipment rows and centered over the aisles.
4. Provide emergency lighting in the ADC.

F. Working clearances of 4 feet shall be provided for all installed ADC equipment. Consider working clearances of 5 feet or more in main ADC corridors and fire egress areas.
1. Clearance between IT and physical infrastructure equipment rows shall conform to the following minimum clearances:
   a. Cold aisles (rack fronts facing each other): 4 feet wide.
   b. Hot aisles (rack backs facing each other): 3 feet wide.

4.4 ELECTRICAL POWER

A. Provide redundant electrical power feeds to the data center building.
1. A single commercial feed sized to support the building and ADC is required. 
   a. The electrical utility service entrance shall be sized to at least 125% of the projected final load.
2. Two backup generators sized to support the ADC’s full load are required. This is a 2N requirement.
   a. Power utilities in the US average 1.86 outages annually with an average repair time of 4 hours. Assuming a mission time of 5 years, an average generator availability of 80%, power distribution uptime of 95%, and an UPS uptime of 80%, the following result (see sketch):
   b. The generator should be sized to at least 125% of the projected final load.
   c. The backup generators should have sufficient fuel to run for 3 continuous days.
   d. Place the generators, mechanical infrastructure, electrical gear, and fuel tanks in a secure enclosure.
   e. The generators should supplement utility power within 30 seconds of utility power loss.
3. The redundant underground power feeds to the building should be placed a minimum of 66 feet apart.
4. Dedicated electrical panels should be placed in the ADC, sized to support the ADC.
5. Electrical infrastructure for the ADC should be isolated from the building’s electrical infrastructure.
6. Transformers, if placed in the ADC, shall be placed a minimum of 4 feet from the pods or cabling.

B. Redundant UPS and PDUs are required.
1. The redundant UPS should be sized to offer 30 minutes of run time.
   a. The commercial electrical feed, dual backup generators, and 30 minutes of battery runtime provides the ADC with three lines of defense for maintaining electrical power.
2. The redundant UPS shall not exceed 80% of its capacity when carrying a full electrical load.
3. UPS and PDUs shall be modular and scalable to allow for ADC equipment growth and consolidation.

C. UPS requirements:
1. Redundant UPS are provided at 2N.
2. The UPS shall be modular.
3. Possess hot swappable power modules.
   a. Provide N+1 power modules as a minimum.
4. Have hot swappable batteries.
   a. Provide N+1 batteries as a minimum.
5. Be manageable with self-diagnostic capabilities.
6. UPS should be scalable.
   a. Be scalable to 500 kVA.
7. Provides maintenance bypass.
a. Possess an external make-before-break maintenance bypass system to electronically isolate the UPS during maintenance and service.
8. Possesses emergency shutdown capability.

D. Power strip requirements:
1. Equip each rack in a pod with a minimum of two power strips, one strip connected to each of the redundant PDUs.
2. The power strip should be rated at 208 V and 60 amps.
   a. Four metered power strips are required in each HPC rack.
3. Provide metered power strips to allow real-time monitoring of connected power loads.
   a. The power strips should be programmable to user-defined alarms to warn of potential circuit overloads before critical failures occur.

E. A notional ADC electrical block diagram is portrayed to the right.

F. Label all ADC electrical components as specified by OIT or CU Facilities:
1. UPS.
2. PDU.
3. Metered power strips.

G. Electrical power filtering and conditioning are highly desired.

H. Power Usage Effectiveness (PUE).
1. Design the ADC to obtain the lowest PUE possible. Strive for a 1.5 PUE, where a PUE of 1.0 is not readily obtainable.
   a. PUE = Total Facility Power/IT Equipment Power.
   b. DCiE = 1/PUE = IT Equipment Power/Total Facility Power x 100%.
   c. IT Equipment Power: includes the load associated with all of the IT equipment, such as compute, storage, and network equipment.
   d. Total Facility Power: this includes everything that supports the IT equipment load. Total Facility Power includes: UPS, switch gear, generators, PDUs, batteries, distribution losses external to the IT equipment, chillers, CRACs, DX units, pumps, cooling towers, compute, network, storage, and miscellaneous component loads such as data center lighting.

I. ADC power planning numbers.
1. Initial W/ft² may be around 150 W/ft².
2. Gross W/ft² may exceed 250 W/ft².
3. Power typically consumed by rack type:
   a. Single telecom rack: 5 kW/hr.
   b. Single server rack: 12 kW/hr.
   c. Single HPC rack: 25 kW/hr.

4.5 HEATING, VENTILATION, AIR CONDITIONING (HVAC)

A. Provide redundant chilled water sources.
1. CUP chilled water is desired as the ADC’s primary source.
2. A suitably sized chiller water farm placed near the ADC is desired.
3. Redundant underground chilled water feeds to the ADC building should be placed a minimum of 66 feet apart.

B. Provide row or rack cooling to support the pods’ thermal requirements.
1. OIT currently uses row cooling pods, but rack cooling may be required.
C. Provide room cooling for utility support units such as transformers, power panels and for people working in the ADC.
   1. Provide redundant 6-ton FCU for room cooling support.
   2. Install the FCU overhead mechanical gear outside of the ADC’s perimeter wall.

D. There are four types of data center cooling: room, row, rack, and direct-to-chip cooling (as portrayed to the right). The ADC shall initially contain room and row cooling, with the HVAC design aimed at supporting future rack and direct-to-chip cooling. The ADC HVAC design should incorporate support for innovative cooling technology.

E. Each pod shall possess exterior cold aisles and an enclosed hot aisle to contain the thermal load.

F. Chilled water leak detection is required.

G. Air filtering is desired to remove harmful contaminants in the ADC.

H. Mechanical infrastructure supporting the ADC should be isolated from the building’s mechanical infrastructure.
   1. No water pipes, sewer pipes, gas lines, etc. should be run in the ADC unless they directly support the ADC.

I. Label all ADC HVAC components as specified by OIT or CU Facilities.

J. Place all active cooling components on the backup generators and UPS.

K. Cooling planning numbers.
   1. Power in equates to heat out.
      a. Single fully filled telecom rack: up to 5 kW/hr.
      b. Single fully filled server rack: up to 12 kW/hr.
      c. Single fully filled HPC rack: up to 25 kW/hr.

4.6 GROUNDING AND BONDING

A. Grounding systems throughout the ADC shall not measure greater than 5 ohms to earth ground as measured by the four-point fall-of-potential method.

B. Provide the following:
   1. Place a TGB in the ADC and ground all active components to the TGB, this serves as a signal ground.
   2. Ground the ADC floor to the TGB to preclude ESD.
   3. Ground the computer room racks to the TGB for personnel safety.
      a. ADC racks, cabinets, overhead cable trays, cable ladders, and wiring troughs shall be bonded throughout their entire structure and bonded to the ADC’s TGB.
   4. Ground pathways to the TGB for personnel safety.
   5. Ensure the TGB is permanently grounded to the building’s TMGB.

C. Place redundant humidification devices in the ADC to maintain a relative humidity from 35% to 45% to preclude ESD.

D. ADC static electricity shall be controlled by the use of moisture barrier protection.
4.7 FIRE PROTECTION

A. The ADC fire suppression system shall be independent of the building system.
   1. The ADC fire suppression system shall appear as a single alarm point on the CCPM Building’s
      main fire alarm panel.

B. Place the following fire detection systems in the ADC:
   1. VESDA fire detection system.
   2. Both heat and smoke detection capabilities are desired.

C. Provide the following fire suppression systems in the ADC.
   1. DuPont FM-200 (HFC227ea), 3M Novec 1230, Inergen (IG541) or other inert or synthetic fire
      suppression system, as recommended by the DCDC and selected by OIT.
      a. The fire suppression system shall be activated by the initiation of any two cross-zoned
         smoke detectors or by manually activating the pull station.
      b. Upon discharge of the fire suppression system, the EPO system shall be automatically
         activated.
   2. Preaction water fire suppression system with high-temperature caged or recessed heads.
      a. Preaction water systems should have rack troughs installed to preclude accidental water
         damage to the ADC equipment.
   3. Class C (or A-B-C rated clean-agent) handheld fire extinguishers shall be placed inside the ADC
      near the doors and other areas as required by the AHJ.
      a. Place a handheld fire extinguisher at 50 foot intervals.
      b. Place a minimum of two handheld fire extinguishers in the ADC.

D. Place the following fire signaling systems in the ADC.
   1. Fire alarm pull stations shall be placed at all ADC doors.
   2. Provide EPO switches connected to the preaction water fire suppression system.
      a. The EPO switch shall, upon activation, shut down all mechanical and electrical systems
         including the closure of fire and smoke dampers.
      1) The EPO button, when activated, shall de-energize the IT equipment in the computer
         room prior to water release.
      b. The EPO switch shall disconnect power to all data center electromagnetic door locks,
         disabling them in the unlocked, open position.
      c. EPO button shall sound a local horn and light alarm when the EPO protective cover is
         lifted.
      d. EPO horn and light alarm shall not resemble the fire annunciation horn and light alarm.
      e. EPO buttons are required at each ADC door.
   3. EPO buttons and fire alarm pull stations shall have safeguard features to preclude accidental
      activation, release, or discharge.
   4. Label all stations to campus standards.

E. The OIT TNI directorate shall place emergency telephones in the ADC.
   1. Emergency telephones shall be located adjacent to any clean agent fire suppression abort switch.
   2. Emergency phones shall be located at each data center exit adjacent to the EPO switches.
   3. Place an emergency telephone adjacent to the fire panel.

F. Place the fire protection panel and annunciator near the ADC’s front door or where stipulated by the AHJ.

G. Perimeter walls shall extend from the floor slab to the ceiling slab.
   1. ADC perimeter walls shall have a minimum 1-hour fire-rating or as specified by the AHJ.
   2. ADC interior walls shall have a minimum 1-hour fire-rating or as specified by the AHJ.

H. A minimum of two doors for egress are required in the ADC or as specified by the AHJ.
I. Place all fire protection equipment on the backup generators and UPS, if possible.

4.8 ELECTRONIC BUILDING SECURITY

A. Place the following security controls in the ADC:
1. University-issued badge card readers at every door, with PIN pad.
   a. Door locks should fail secured (fail closed).
2. Install University Electronic Building Security cameras to monitor cold aisle and hot aisle personnel actions.
3. Place cameras to monitor all ADC doors.
4. Hot aisle doors may be lockable, but they must have an emergency override function.
5. Racks should be equipped with a university-issued card access control system.
6. Install access card readers with PIN pad in the auxiliary OIT office area adjacent to the ADC:
   a. ADC Operations Center.
   b. ADC supply and storage room.
   c. ADC shipping, receiving, and equipment staging area.

B. Place all Electronic Building Security infrastructure components on the backup generators and UPS, if possible.

4.9 PERSONNEL SAFETY

A. Place a safety board in the ADC.
1. Place a first aid kit on the safety board.
2. Place a dispenser for disposal ear plugs.
3. Position an ESD wrist strap dispenser in the ADC on the safety board.
4. Place a wooden cane on the safety board.

B. Ensure high-powered electrical systems are labeled for arc flash safety.

4.10 OIT TELECOMMUNICATIONS and NETWORKING INFRASTRUCTURE (TNI)

A. The project will provide redundant underground telecommunications pathways and feeds to the ADC building placed a minimum of 66 feet apart.

B. The OIT TNI directorate shall design, build, commission, administer, validate, and label the redundant networking and telephony services placed in the ADC, NIC.
1. Provide a VoIP telephony system.
2. Design, develop, and coordinate a network data center support topology.
3. Provide redundant Cisco core capabilities in the ADC.
4. Provide a Cisco IEEE 802.11ac wireless overlay inside the ADC.
   a. Consider deploying a minimum of three APs in the ADC.
5. Provide a Corning MobileAccess DAS to extend the CDAS into the ADC.
   a. Consider adding a minimum of two antennas in the ADC.
6. Funding provided by the ADC project.

C. The RCDD/DCDC shall recommend a structured cabling system for implementation in the ADC.
1. Recognized media includes:
   a. Single mode fiber.
   b. Laser-optimized 50μ multimode fiber.
   c. Category 6 or Category 6a UTP, as specified by the OIT TNI directorate.
   d. Other media as explicitly approved by the OIT TNI or OIT Data Center directorates.
2. Hot aisle cable management preferred.

D. Place all OIT TNI telecommunications hardware on the redundant backup generators, UPS, and PDUs.
4.11 OIT SECURITY

A. The OIT Security directorate shall design, build, commission, administer, validate, and label a firewall and IPS in the ADC, NIC.
   1. Funding provided by the ADC project’s budget.
   2. Place all OIT Security directorate firewalls and IPS on the redundant backup generators, UPS, and PDUs.

4.12 OIT COMPUTING INFRASTRUCTURE (CI)

A. The OIT CI directorate shall design, build, commission, administer, validate, and label the computing environment consisting of servers and HPC placed in the ADC, NIC.
   1. Provide a virtual environment to support the ADC’s computing environment.
   2. Funding provided by the ADC project’s budget.
   3. Place all OIT CI directorate computing solutions on the redundant backup generators, UPS, and PDUs.

B. The OIT CI directorate shall design, build, commission, administer, validate, and label the storage solution placed in the ADC, NIC.
   1. Provide a scalable SAN to support the ADC’s storage requirements.
   2. Provide a scalable backup strategy and solution, if required.
   3. Funding provided by the ADC project’s budget.
   4. Place all OIT CI directorate storage hardware on the redundant backup generators, UPS, and PDUs.

4.13 OIT DATA CENTER ADMINISTRATION

A. The OIT Data Center (DC) directorate will design administer, configure, and maintain the ADC.
   1. The OIT DC directorate shall develop ADC policies and work rules and train ADC users on the policies and rules.
   2. The OIT DC directorate will provide periodic training to ADC users on the fire protection systems and other pertinent systems.
      a. Identify the Facilities phone number users should use for calling-in outages.
      b. Ensure the OIT DC directorate is notified of these outages.
   3. Post critical ADC operating procedures so they are readily available for review.
   4. The OIT DC directorate will setup procedures for doing routine preventative maintenance on the fire protection system, generators, CRACs, and UPSs.
      a. Schedule routine ADC cleaning.
   5. Identify spare parts desired for the UPS, metered power strips, and other ADC systems.
   6. The OIT DC directorate will assign equipment placement locales to ADC tenants by rack and pod. They will inspect all equipment installation efforts to ensure they comply with OIT safety, cleanliness, and aesthetic standards.
      a. Installations that are not approved by the OIT DC directorate because of OIT safety, cleanliness, or aesthetics issues will be denied commissioning.
   7. The OIT DC directorate shall maintain the overall appearance of the ADC so it projects competency and professionalism.
   8. Develop an ADC fee-for-service cost model in conjunction with the OIT CI directorate.

B. The RCDD/DCDC designer shall recommend a Data Center Infrastructure Management (DCIM) system to the OIT DC directorate for possible procurement.

C. Place a sign-in log at the ADC entrance.
   1. University badged employees who have access to the ADC do not need to sign-in. All others do.
      a. Tours led by an authorized user with ADC access do not need to be logged in.
   2. Escort all vendors who need access to the ADC after they have signed in.
3. Maintain the sign-in logs for one year.

D. The ADC will generally be staffed from 8 am to 5 pm, on regular AMC business days.

E. Ensure all racks, PDUs, CRACs, UPS, and other significant components are labelled to university and OIT standards.

END OF SECTION 27 62 01
SECTION 28 00 00 - ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

A. SECURITY DESIGN PROCESS Concept Design (5%)
   1. Two sets of drawings and two sets of specification books to the ESD and its contractor(s).
      Drawings to also be provided to security contractors in electronic format, (AutoCAD 2000 or
      higher, .dwg), where possible.
   2. Security requirements identified, after initial and concept design conferences:
      a. Controlled Portals
      b. Monitored Portals
      c. CCTV Surveillance
      d. High Value and High Risk Areas
      e. Interior compartmentalization needs
      f. Adjacency and Campus Integration Issues
      g. Areas of regulatory or compliance requirement
   3. Hand out worksheets and conference notes
   4. Discuss project and establish security preliminary budgets as part of the overall construction
      budget.

B. Schematic Design (35% documents)
   1. Two sets of revised drawings to ESD and security contractor(s) (electronic and paper)
   2. Continued participation in all design conferences
   3. Review space configuration and design narrative
   4. Security conferences with tenants to ascertain work processes, occupant flow, risk analysis, hours
      of operation, compartmentalization issues, public access, high value areas, etc.
   5. Security conferences with security contractor(s) to ensure security overlays are sent to architect
   6. Security conferences with the electrical contractor and the supplier of door hardware regarding the
      integration of components

C. Design Development (65% Documents)
   1. Two sets of revised drawings to ESD and security contractor(s)
   2. Continued participation in all design conferences
   3. Review interior building configuration and elevations
   4. Resolve security specifications and update overlays
   5. Continued refinement of project costs and schedule with security contractor(s)
   6. Construction Documents (95% Documents)
   7. Two sets of revised drawings to ESD and security contractor(s)
   8. Continued participation in all design conferences
   9. Continued audit of revised drawings to security specifications
   10. Continued revision of costs and construction schedule with security contractor(s)

D. Construction (100% Documents Final)
   1. Two sets of revised drawings to ESD and security contractor(s)
   2. Continued participation in all design conferences
   3. Construction schedule with security contractor(s)
   4. Construction delivery and coordination
   5. Participation in contractor/subcontractor site conferences

E. Accepting the Security System by ESD
   1. Review security processes and signoff requirements of GC
   2. A commissioning check list will be developed for each project
   3. A functional test of all systems before acceptance is complete.

END OF SECTION 28 00 00
SECTION 28 13 00 - ACCESS CONTROL

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. The University of Colorado Denver | Anschutz Medical Campus Physical Security Standards

1. 1.2.2.1. The University physical security standards for the campuses set the baseline of security requirements for each building and all controlled access structures/areas. The primary objective of the physical security policies and standards is to protect people first, with property, research protocols, and intellectual property behind it.

2. When incorporated into building design, the University will enjoy a continuity of application between each building and each zone. Architectural considerations for the presentation of buildings should incorporate these standards and the CSI, as a whole, as representative of the University’s security position.

3. The University uses a layered approach to security provision. It defines this as the provision of barriers and distance between the area protected and public areas, with security provided to the object(s) of protection first and then working outward with additional layers, as needed. Layers will be added to ensure that response time by the University Police is always less than the attack time against the object(s) of protection. Barriers will allow permitted passage but will also provide a time delay or physical deterrent for non-permitted entry. Alarm, CCTV, and/or data logging by the Security Department monitors the effectiveness of these barriers. The University Police Department also monitors these barriers by foot, vehicle patrol, and remote use of the CCTV system. The greater the value or risk of the protected area, the greater the perimeter and barrier protection.

4. The standards are dynamic in that they are an appropriate and timely reaction to identified risks with reasonable mitigation to those risks, consistent with physical, technical, and fiscal restraints. As the risk changes, the associated security will react and change appropriately. However, the University will provide a baseline level of protection to all structures.

5. The standards are oriented to support the widely varied work processes; to promote the fact and perception of personal security and safety; and to address compliance with state, municipal, and industrial standards set in code, law, or policy.

6. The “Cost of Security” includes the cost of design/installation; procurement of components, monitoring of alarms and trouble alerts; response to alarms; periodic design review, and system maintenance. Indirect costs of security include the monitoring staff, the Security Badging Offices staff, training, and supplies. All primary exterior entry portals, loading dock portals, and other frequent access points in the perimeter wall will have card reader controlled access. The equipment set for these doors will include HID RP40 (CR), Von Duprin 6000 Series Electric Strikes or Locknetics Maglocks, Request for Exit device (RTS), Door Position Sensor (DSM), and Code Blue 2-button CB-3000-d Intercom Device (IC) to reach Access Control or the Police, and other components as technology, requirements and risk require. All exterior doors to all buildings will have access control or door position monitoring enabling UCD to ensure a secure perimeter of each building after the close of business. The University installs access control devices at a building’s primary entrance(s), where the area secured must limit access to a large and variable population, where the contents of the area present a high value or a high risk of injury; where after-hours access must be logged, and/or where unique circumstances require monitored access control. All buildings will have, by default, at least one card controlled door in its secure perimeter.

a. Security relative to research laboratories, and other restricted zones adjacent to public areas within the same building will have secure perimeter. All doors to the laboratory spaces will have access control devices or will be alarmed and signed for emergency exit only. Each lab will have two secure barriers: the building exterior and an interior door system. The interior doors that are alarmed and controlled will remain secured at all times to ensure that only authorized personnel can enter, that a secure fire perimeter is supported, and that the line between biological, chemical, and radioactive hazards is enforced. The Security
Department, the Fire/Safety Office, and the Environmental Health & Safety Department have an interest in the security of the laboratory perimeter.

b. All exterior secondary portals used for unrestricted daytime passage and night egress after building closure, will be monitored. These doors will have DSM and RTE. This kit will allow egress without alarm initiation but no reentry after building closure.

c. All exterior portals used for fire or emergency exit only will have DSM only. Exit at any time will initiate alarm. Entry is not permitted at any time. No exterior door hardware is installed.

d. Exterior portals that access mechanical and electrical rooms but do not allow further access into the building will be monitored with a RTE and DSM only and will have time zone alarms.

e. Interior portals that serve to restrict access to a variable, large, or logged population during or after business hours will have HID RP40 CR, Electronic Door Lock Hardware, DSM, and RTE. Depending upon the work process, these portals can be unlocked during certain hours. If the door is in the egress path and there are no mechanical over-rides on the door, a fire pull device may be required.

f. Interior portals that provide security only during non-business hours and where free flow of traffic is necessary, may be held in the open position with magnetic hold-backs (MH) which will release at a specified time allowing the door to close to secured and monitored state. These portals require MH(s) and DSM(s). Access can be via key for emergency over-ride or access control card key, depending upon the size and type of the permitted population.

g. Interior portals that secure office, classroom, electrical, mechanical, audio-visual, maintenance, conference and similar areas will typically be secured by door hardware only, tied to the keying schema of the university.

h. High Value, High Risk, or Privacy Protection Areas will be secured by the normal CR, RTE, and DSM kit with the CR replaced or supplemented by a Biometric Device (BD) that incorporates the proximity reader and digital fingerprint to gain access. Use of these devices is dependent upon the risk mitigated by the locked door. These portals will be locked and controlled at all times and may have CCTV surveillance to support the security controls.

i. Elevators, passenger and freight, may have access control features to provide floor by floor compartmentalization during or after business hours. These may include a card reader at entry floors to open a car and interior readers to support permitted access to selected floors. Supporting features may include CCTV surveillance at elevator entry points or inside the cars to record tail-gating events, movements of property, or irregular access events.

j. Fire Stairwells will have access controls to particular floors when the elevators on corresponding floors have access controls. As with elevators and all fire egress paths, the fire system will shunt any security devices in the egress path. Egress to the roof will be prevented by locked keyway only. Re-entry to intermediate floors, though not required by code, may be designed to provide escape routing should an occupant be confronted by criminal or other personal threat between the tenant and ground level egress. Where those floors are identified, a fire pull station will be installed. Initiating this alarm will summon fire and police. The Security Department and the University’s Fire Marshal will work with the Architect on this issue.

k. The CCTV and Security systems will terminate in the IT/Telecom room(s) core in each structure. Security will typically have one wall for its low voltage power supplies, controllers, etc. and a portion of the rack system for its DVR, UPS, etc. These rooms also support the fiber optic breakout, the structure’s telephone and network features. Security will bridge to the campus network in these areas.

l. The Security Department supports the widely accepted “Crime Prevention Through Environmental Design” concepts that include the security program involvement during the designs of interior, exterior, landscape, lighting, parking, loading, etc. The Security Department also supports the AIA’s “Building Security through Design” concepts that encourage early integration of risk identification and risk mitigation through seamless design features. The Security Department will contribute to the Project Team throughout March 1, 2012
the structure’s development to ensure clear communication, quick consultation, and solid research.

7. Secure Perimeters
   a. All exterior doors to all buildings will have access control or door position monitoring enabling UCD to ensure a secure perimeter of each building after the close of business.
   b. The University installs access control devices at a building’s primary entrance(s), where the area secured must limit access to a large and variable population, where the contents of the area present a high value or a high risk of injury; where after-hours access must be logged, and/or where unique circumstances require monitored access control. All buildings will have, by default, at least one card controlled door in its secure perimeter.

PART 2 - PRODUCTS

2.1 ELECTRONIC ACCESS CONTROL SYSTEM COMMAND AND CONTROL – ACCESS CONTROL CENTER

A. C•CURE FOUNDATION SECURITY FEATURES
   1. The software suite selected to drive the integrated campus security, alarm and CCTV systems is C•CURE 8000 by Software House, a Tyco Company. The university may migrate to CCURE 9000 in the future but performance and design standards will remain as described. The specifications of the software of published at the Software House website: http://www.swhouse.com/
   2. Wiring specification:
      a. Access Control:
         1) Card Reader – 1 (one) 18/6 shielded
         2) Door position switch – 1 (one) 22/4 conductor
         3) Locking hardware – 1 (one) 16/2 conductor
         4) Request to exit – 1 (one) 18/4 conductor
         5) Emergency door release - 1 (one) 18/4 conductor

<table>
<thead>
<tr>
<th>Cable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>18/6</td>
<td>18-6C STR BC FRPVC FOIL SHD FRPVC JKT WHT CL3P</td>
</tr>
<tr>
<td>18/4</td>
<td>18-4C STR BC FRPVC FRPVC JKT WHT CL2P</td>
</tr>
<tr>
<td>16/2</td>
<td>16-2C STR BC FRPVC FRPVC JKT NEC CMP WHT</td>
</tr>
<tr>
<td>22/4</td>
<td>22-4C STR BC FRPVC FRPVC JKT WHT CL3P</td>
</tr>
<tr>
<td>RG59</td>
<td>SIAMESE:RG59 20 SOL BC FFEP 95 BC BRD+18-1P STR BC NAT FRPVC JKT CMP CCTV</td>
</tr>
<tr>
<td>22/2pr Shld</td>
<td>22-2P STR BC FRPVC IND FOIL SHD FRPVC JKT NAT 300V 60C CMP</td>
</tr>
<tr>
<td>Fiber 4 strand</td>
<td>BX-04-070K-WLS/900-OFNP 4 STRAND BREAKOUT CABLE</td>
</tr>
<tr>
<td></td>
<td><em>(Fiber MINIMUM RADIUS BEND 4.13 INCHES)</em></td>
</tr>
</tbody>
</table>
2.2 ESD is the primary contractor for security features on the campus. ESD will provide the equipment specifications for all security and CCTV systems.

2.3 ESD will resolve subcontractor issues regarding wire installation, etc. with the Project Manager and the General Contractor. When possible, the ESD will address the installation of all components at the terminus and the control panels but will likely utilize the General Contractor’s resources for pulling wire between the various ITS rooms and the various end points.

2.4 CARD READER DOOR SET UPS

A. Primary Doors:
1. HID RP40 Card Readers (Exterior doors), DS150i Request to Exits, Sentrol 1076-N Door Position Switches, VonDuprin 6000 Series Electric Strikes or Locknetics Maglocks
2. Other Doors
3. HID RP40 Card Readers (Interior doors), DS150i Request to Exits, Sentrol 1076-N Door Position Switches, VonDuprin 6000 Series Electric Strikes or Locknetics Maglocks
4. HID RP15 Card Readers (Mullion Mount), DS150i Request to Exits, Sentrol 1076-N Door Position Switches, VonDuprin 6000 Series Electric Strikes or Locknetics Maglocks

B. Non Card Reader Doors
1. Electronic Controlled/Programmed
   a. DS150i Request to Exits, Sentrol1076-N Door Position Switches, VonDuprin 6000 Series Electric Strikes or Locknetics Maglocks
2. Electronic Monitored
   a. T-REX-XL2ADT Request to Exits, ADT1076-N Door Position Switches

2.5 SECURITY SYSTEMS AND ALARM TYPES

A. Door alarm – Forced Open and Held Open alarms will be broadcast when a door is opened except by the appropriate security device and when the door is held open for more than two minutes. Overhead doors will broadcast an open alarm when open during an alarmed period.

B. Intrusion Alarms – Intrusion alarms are triggered when a room or building which has a security perimeter and interior motion detection devices installed has a motion detection or perimeter breach.

C. Panic alarms – Panic alarms are installed where cash or other high value is located; where risk of injury is high or where intrusion risk is present. All alarms trigger a police or a police/EMS response to the alarm location.

D. Motion Alarms – Where a device is selected to detect the presence of a person for alarm purposes, dual technology (microwave and infrared) sensors are co-located in a devices for that purpose. The type of infrared sensor installed to function as a Request to Exit device (RTE) is installed on the secure side of a door to shunt alarms upon exit.

E. Access Control for Elevators – Access to floors with controlled access will be controlled by card readers installed in the car. If the car opens to a secure floor, into secure space, a building’s roof, or other hazardous area access to that floor will be controlled.

F. Automated External Defibrillators – Provide a 22 gauge, four conductor stranded cable routed from the AED enclosure to the nearest Security Control Panel with external relay connection to the University Police. Coordinate with the University Electronic Security for terminations on both ends.

G. Uninterrupted Power Supply (UPS) must be identified for all Digital Video Recording (DVR) equipment. The UPS must be able to support the loss of power for .25 hours. It shall provide power conditioning and
EPS (Emergency Power System) buffering. The circuits supporting DVRs must also be supported by the emergency power generation system for the building.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 28 13 00
PART 1 - GENERAL

1.1 SUMMARY

A. This section provides standards on the design and products to be used in facility video surveillance.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. The University of Colorado Denver | Anschutz Medical Campus uses CCTV systems as an integral part of its physical security system. Cameras may be placed on building roofs, at key buildings entries, at central interior junctions, and in areas of high value or high risk. The placement and visibility of cameras should not infer that each or any camera is monitored at all times, that a particular action or reaction may take place because of the presence of a camera, or that a camera, by itself adds to the security or safety of a particular area.

1. Closed Circuit Television (CCTV) devices whether fixed or pan, tilt, zoom (PTZ) will be placed to record access to and activity in sensitive areas; areas where cash, drugs, merchandise, and other high value items are maintained; and where personal protection, property theft, or personal safety risks are identified. These will typically be in selected interior spaces, at primary entry portals, and selected roof locations. Low or zero light cameras will be installed where surveillance is critical even in zero light conditions.

2. Certain grants, contracts, donors, work processes, etc. have unique security requirements attached to their funds, equipment being used, or processes in the university setting. The Security Department will respond to those with developments, as needed and requested with CCTV, physical security or other features to address contractual or grant mandates.

3. Emergency Communications – The University has adopted the “Code Blue” emergency telephone system placed in parking, pedestrian, selected entry portals, and others areas as noted in the Master Plans for the site. If the construction of a structure, pathway, road, etc. or the combination of adjacencies among structures increases the need for additional telephone units, these should proposed and coordinated with the Security Department and the Police Department. The Information Technology Department is responsible for this telephone system, although placement and selection is coordinated with the Security Department. Exterior poles should include support for PTZ cameras mounted on the standard “J” hook accessory.

4. Elevators, passenger and freight, may have access control features to provide floor by floor compartmentalization during or after business hours. These may include a card reader at entry floors to open a car and interior readers to support permitted access to selected floors. Supporting features may include CCTV surveillance at elevator entry points or inside the cars to record tail-gating events, movements of property, or irregular access events.

5. The CCTV and Security systems will terminate in the IT/Telecom room(s) core in each structure. Security will typically have one wall for its low voltage power supplies, controllers, etc. and a portion of the rack system for its DVR, UPS, etc. These rooms also support the fiber optic breakout, the structure’s telephone and network features. Security will bridge to the campus network in these areas.

6. New Construction, Remodeling and Renovation Standards
   a. The University has set construction and renovation standards in the areas of physical and electronic security to enhance the efficiency and effectiveness of new construction, renovation, relocation of offices and labs; and the integration of all work functions on both campuses. This document (CSI Division 280000) resides with the Facilities Projects Department and is distributed it to all new building design teams. As projects are developed, the security requirements are incorporated from the concept designs through to commissioning of the structure.

B. Personnel Security
   1. At each primary door entry and in all parking areas, “Code Blue” pylons have been installed.
PART 2 - PRODUCTS

2.1 Closed Circuit T.V. Cameras provide by the University

A. Camera Wiring:
   1. Fixed Cameras require
      a. RG6/18-2 Siamese for runs 750’ or less
      b. RG59/18-2 Siamese for runs 500’ or less
      c. Other wiring requirements will be determined by application
      d. All Camera wire jackets to be Grey in color

   2. PTZ Cameras require
      a. RG6/18-2 Siamese for runs 750’ or less (Video)
      b. RG59/18-2 Siamese for runs 500’ or less (Video)
      c. 18-2 type wiring (Data) Or as specified by the Manufacturer(s)
      d. Other wiring requirements will be determined by application
      e. (All Camera wire jackets to be Grey in color)
      f. ADD AC Power requirements (protected box at roof level)

2.2 CCTV Monitor:

A. Provided by the University.

2.3 Digital Video Recording

A. American Dynamics Intellex, rack mount, 16 channel, v4.1 or higher software, premier 480GB, NTSC
   provided by the the University.

B. Location
   1. AC Power and Data Drop for Monitor. Back Box kit, hang flush on wall.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 28 23 00
SECTION 28 31 00 - FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Provide a microcomputer based system using multiplex techniques for alarm reporting, central monitoring, signaling, and selection of audible and visual signal circuits. The fire alarm system should be capable of making emergency announcements. The fire alarm subcontractor should work closely with the campus Information technology department working through the University Project Manager to make this work.

B. Provide individually identified fire alarm sensors; pull stations, indicating devices, and compatible monitor and control devices. Provide a unique address for each device 8 digit only, with operator-assigned English language descriptor.
   1. The system shall include the following major components
      a. Fire Alarm Control Panel (EST3)
      b. Fire Alarm Annunciator Panel (FAAP) and LCD Display.
      c. Fire Alarm Voice/Evacuation Panel (FVEP)
      d. Fire Alarm Computer Terminal (FACT) – FACT refers to the individual building and University Police Building FACT.
      e. Fireman Two Way Telephone Panel (FTP) – If required by the building type.
      f. Digital Alarm Communicator Transmitter (DACT) (3-Mod Comp)
      g. Interface with campus overhead Emergency Paging system with Central Station monitoring computer controls.
   2. Conventional fire alarm initiating devices (smoke detectors, heat detectors, manual stations, water flow and tamper switches, pressure switches) shall each be individually addressable via, and shall report to the FACP.
   3. Control relays shall be individually commanded by the system to respond automatically in case of an alarm by related sensors or other devices. Manual control of fans, dampers and required relays shall be provided, as well as automatic control where required by code. Control sequences shall be as indicated on related mechanical systems control drawings.

C. The system shall operate as a low voltage, zone-annunciated Fire Management System and shall include the following subsystems:
   1. FACP to monitor addressable initiating and control devices, annunciate the alarm device exact location, initiate alarm and evacuation signals, and capture and recall elevators.
   2. FACP and Associated Auxiliary panels shall be provided with Class “A” wiring.

D. Provide UL listed system. If required as a condition requisite to establishing UL listing of the entire installation as a system, the Contractor shall arrange for, and pay all costs associated with, any required off-site or on-site review, supervision, and/or inspection which may be required for gaining such UL listing.

E. Conform to the following NFPA requirements:
   1. Initiating Device Circuits (IDC) shall be Class B
   2. The Signaling Line Circuits (SLC) shall be configured as follows:
      a. Class A for signaling line circuits connecting intelligent devices to the FACP.
      b. Loss of connectivity between FACP and the facility’s Central Control FACP shall not hamper functions of the fire alarm system within the building.
   3. The Notification Appliance Circuit (NAC) shall be Class B
F. ANSCHUTZ MEDICAL CAMPUS SYSTEM LAYOUT
1. General:
   a. All campus buildings will be equipped with a FACP. Locate near the main entry and a
      FVEP located near the FACP per the building design, for all non high-rise buildings.
   b. Each FACP shall be networked into the campus network and accessible from the Campus
      FACT. Any FVEP shall be accessed from the Campus FCC FVEP microphone and/or the
      Campus Police Station FVEP microphone.
   c. One FACP and FACT in one university high-rise building FCC and one university high-
      rise building FCC will be designated alternate locations for the Campus FCC FACP. All
      information residing in the FACP/FACT of the Campus will be duplicated at these two
      locations.
   d. A FACT with FAP or a FAAP with LCD indicating building in alarm shall be located at
      the University Police Building. The Police Station shall be capable of accessing any FVEP
      via local microphone.
   e. Every building will be equipped with a weatherproof speaker/strobe located at each
      exterior door.
   f. Include the Following Front Panel Controls:
      1) Each floor shall have a disable button
      2) Elevator disable
      3) Fan/shut-down disable
      4) Pager disable
      5) Door disable
      6) Separate speaker and strobe disable
      7) Manual page by floor
      8) NETCOM DISABLE
      9) BAS DISABLE

G. Provide interface with the Building Automation System to report all “alarm” and “supervisory” actions. 
Refer to Division 23.

1.2 PERFORMANCE REQUIREMENTS

A. General:
   1. Normal operator interface, through the FACP located in each individual building where required, 
      and at the designated FACT located in the Anschutz Medical Campus University Police Building
      in the Police Dispatch. All system early-warning pre-alarm, alarm, and trouble messages shall be
      annunciated on the FACT in a color-graphic format with English language descriptors.

B. High-Rise Buildings.
   1. The fire alarm sequence of operation shall be in accordance with the requirements for high-rise 
      buildings, including but not limited to the following:
      a. The alarm and activate the strobes for the floor in alarm and the floors above and below.
      b. Initiate stair pressurization and where used, initiate pressurization of the floors above and 
         below the floor in alarm.
      c. Release of stair, held-open doors, and re-entry doors.
      d. Upon activation of the elevator, elevator shafts, or elevator lobby detectors, recall the 
         elevators to the main exit level or alternate floor.
      e. Activate refuge area communications link.
      f. Annunciate the alarm to the building FACP, and FAAP, and to University Police FACT.
      g. Annunciate the alarm condition and location to the building FAAP and local floor FAAP.
   2. The Command Center of the High Rise Buildings shall also be equipped, under another contract, 
      with the following remote status/control panels:
      a. Buildings electrical distribution system.
      b. Building fire pump.
      c. Elevator status and control panel.
d. Building voice paging system and/or voice evacuation system (i.e., Office Building) via
zone interface panel and microphone.

e. CCTV system monitors and keyboard.

f. Smoke control panel.

g. Generator control panel.

3. The FD will use these panels for viewing or controlling each of the above systems.

C. The FD will respond to the FACP of the building in alarm and to the Campus Police. The Campus Police
FACT shall be automatically activated into the graphics mode to show the current status of all devices in
alarm. The FD will take command of the Building's FACT to monitor the current response to the fire
alarm condition. Using a "mouse driven" graphic menu, the FD shall be able to "zoom in" or "zoom out"
of the graphic screens to view the current alarm condition.

1. The FD will use the building's FCC PC graphic system to view and control the response of the fire
alarm system by viewing special graphic screens such as:

a. A smoke control system status and control screen.

b. Any building within the complex connected to the fire alarm system.

c. Any preprogrammed screen existing within the fire alarm system.

d. Or other specialty screens that may be created at the request of the university Facilities
   Operations.

2. Using the assigned FD Identification Code (ID password), the FD may use the FCC PC to alter the
preprogrammed fire fighting response to the present alarm condition. A printer will provide hard
copy documentation of all alarm conditions, ID password log on commands, and the system
response to the specific fire alarm condition.

D. The Campus Control Center fire alarm computer will provide monitoring and secondary back up of the
fire alarm computers located in the various fire command centers. If an equipment trouble alarm is initiated
from a fire alarm device, it shall be reported at the FCC FACP of the building in alarm and the Campus
Control Center PC.

E. If a fire alarm condition is received and the FD cannot initiate an appropriate response from the building's
FCC PC (i.e., fire in the Buildings' FCC room, or a failure of the FCC PC), then an override ID password
command can be used by the FD to make any system PC the primary PC for the manual fire fighting
override response. The selected PC shall be able to alter a building's preprogrammed response to the
alarm condition. The selected PC shall be able to access and control all PC graphic screens that reside
within the system.

F. It shall be possible for all authorized personnel, using the proper ID password, to place the facility into
smoke control operation through the graphic screens from the University Police (FACT), or the Building's
FCC FACP.

G. Automatic Actions:

1. Activation of an alarm-initiating device, as specified herein shall cause the following:

a. Annunciation of the alarm condition, type, and device address at the FACP, FACT and
   FAAP in a LCD format at the building FAAP. An audible signal shall sound and the alarm
   condition shall flash until acknowledged. The alarm condition and its location shall also be
   displayed at the University Police FACP, FACT, and FAAP per the building design.

b. The appropriate audio and visual alarms shall be transmitted throughout the building in
   alarm or to predetermined zones of the building in alarm.

c. Disable the elevator call system and recall the elevators to the level of discharge exit or to
   the alternate floor.

d. Initiate smoke control procedures and functions automatically (position dampers and
   control fans) from the building FACP.

e. Release self-closing fire and smoke doors in specified control zone when the system goes
   into alarm.

f. Provide control relay at each access control panel to unlock all secured doors in activated
   control zone.
g. Provide digital paging notification to select university personnel as determined by the University Project Manager.

2. Provide smoke detector circuits with alarm verification with field-adjustable time from 0 to 60 seconds. Only verified alarms shall initiate the specified sequences.

3. Activation of a sprinkler valve supervisory switch shall initiate supervisory alarm at the corresponding building FACP, FAAP, FACT, and FAP and initiate a supervisory alarm signal at the University Police FACT. Supervisory alarms shall be differentiated from a trouble condition on the circuit.

4. A break in the initiating circuit or detector power wiring shall be annunciating as a trouble condition on the building FACP and the University Police FACT.

5. A break in the audio/visual circuit wiring shall be annunciating as a trouble condition on the building FACP and the University Police FACT.

H. Failsafe Operation: To increase the system's ability to survive damage from fire, malicious or accidental damage, premature component failure, etc., the fire alarm system shall provide the following functionality:

1. Each building FACP shall operate in a stand-alone manner, independent of any other FACP or FACT. The building FACP shall contain the complete data file for all connected devices, regardless of the building, and shall operate the same way whether connected to any other FACP or FACT. This includes:
   a. Annunciation of device address and condition. One hundred percent of all connected devices shall be capable of operating for alarm simultaneously.
   b. Logical Point Grouping annunciation and control. Each Logi-cal Point Group shall contain up to 15 physical points and shall be capable of initiating a sequence of control actions.
   c. Event-initiated control, signaling and/or annunciation sequences. One hundred percent of all connected devices shall be capable of being operated simultaneously.
   d. Priority display of multiple alarms.
   e. Complete supervision of all connected devices with no degraded operation.
   f. Complete reset capabilities at FACP and FACT.

2. Standby batteries capable of operating the FACP, FACT (except those supported by non-interruptible power supply systems), FAAP, FVEP, smoke detectors and alarm horns, strobes, secondary PC terminals, video display units and printers, shall be provided to automatically back up the emergency power source. The system shall have the capacity to operate FACP, as required per NFPA PCs for two hours, and then operate the fire alarm indicating devices for at least 15 minutes, per NFPA requirements. When commercial power is restored, the system shall transfer automatically to primary power. System power supply shall be equipped with battery charging circuits sufficient to recharge fully depleted batteries to within 70 percent of their maximum capacity within 12 hours.

3. System operating software and data file shall be resident in nonvolatile memory. Loss of power, momentary or for a sustained period shall not require reloading of the software.

4. All plug-in circuit boards shall be electrically supervised to assure that the proper board is in the proper position. Systems that use electrical continuity to supervise the presence of plug-in boards, but that do not assure that board positions have not been exchanged, shall provide additional means for the specified supervision, beyond that provided by locking covers.

5. The FACT shall be provided with battery backup or individual dedicated UPS.

I. Color code and minimum wire sizes for the fire alarm system as follows:

1. All wire is solid copper;

2. All insulation colors shall be continuous for the full length of the wire.
3. Wire Jackets shall be stamped with the “Circuit Type” designation or shall have an affixed label designating the “Circuit Type” every twenty lineal feet at a minimum.

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Colors</th>
<th># Of Conductors</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiating Circuits</td>
<td>(+) Red</td>
<td>2</td>
<td>18 (THHN)</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signaling Circuits</td>
<td>(+) Red</td>
<td>2</td>
<td>16 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaker Circuits</td>
<td>(+) Orange</td>
<td>2</td>
<td>14 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strobe Circuits</td>
<td>(+) Yellow</td>
<td>2</td>
<td>14 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Fighter Phone Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 Twisted/ Shielded</td>
</tr>
<tr>
<td></td>
<td>(-) White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Fighter Phone Riser Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 Twisted/ Shielded</td>
</tr>
<tr>
<td></td>
<td>(-) White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RS-485 Circuit</td>
<td>(+) Blue</td>
<td>2</td>
<td>16 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Gray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damper Control</td>
<td>(+) Red</td>
<td>2</td>
<td>14 THHN</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AHU Shutdown Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 THHN</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24VDC Power Circuit</td>
<td>(+) White</td>
<td>2</td>
<td>14 THHN</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Alarm Remote Light Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>18 THHN</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaker Phone Cut Out Circuit</td>
<td>(+) Orange</td>
<td>2</td>
<td>14 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Level Audio Riser Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 Twisted/ Shielded</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Level Audio Riser Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door Holder Circuit</td>
<td>(+) Red</td>
<td>2</td>
<td>14 Twisted</td>
</tr>
<tr>
<td></td>
<td>(-) Black</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

J. Intelligent Features:
1. The following additional features shall be provided:
   a. The fire alarm detector cleaning shall be annunciated at the FACP as a trouble condition by the device.
   b. Dual Alarm threshold for day or night settings.

K. Interface With Other Systems:
1. Interface design of fire alarm system with closed circuit television (CCTV) system and FO signal transmission system.
2. The Electronic Security Department (ESD) will provide software to interface with the CCTV and fire alarm systems. CCTV and fire alarm manufacturers shall provide software protocol, for their systems, to ESD.
3. Consultant may purchase copy of specifications for interfacing systems from the university for the purpose of determining interfacing requirements.
4. Interface voice notification with the campus RAV system.
1.3 SUBMITTAL

A. Provide shop drawings as follows:
   1. Floor plans with device layout, address and wiring.
   2. FACP layout.
   3. Riser diagrams.
   4. Battery calculation.
   5. Sequence of operation
   6. Equipment cut sheets
   7. FAAP layout.

B. CADD generated layouts for FACT screen graphics.

C. Operating and Maintenance Manuals.

D. Project Record Documents:
   1. Prior to submittal of the as-built documents, submit a complete package of shop drawings to the university Facilities Operations Fire and Safety office for review. Drawings shall include floor plans and graphic maps for each building and/or floors.
   2. Submit record documents in accordance with the requirements of Section 01 78 39 and the following:
      a. As-built point-to-point wiring diagrams depicting every device, including correct university room numbers.
      b. Revised schematic, wiring, and interconnection diagrams of all circuits, internal and external, for all equipment installed and exact locations for all devices. These schematics shall include the conductor color-coding and terminal number identification system, location of all terminal boxes complete with numbering and each device address.
      c. Complete, as-installed, riser diagrams indicating the wiring sequence of all alarm initiating devices, supervisory devices, and all signaling appliances on all signaling circuits.
      d. A complete description of the system operation, including a schedule of relay abbreviations used on the drawings, list of relay functions, and the sequence of relay operation during supervisory trouble and alarm conditions.
      e. Complete wiring and control diagrams for control and shutdown circuits for fan systems.

1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in Intelligent Fire Management Systems.

B. Installer: Company with certified personnel specializing in smoke detection and fire alarm systems with five years' documented experience as a fire alarm installing contractor.

C. Fire Management system installer shall keep all smoke heads in the building covered until final building turn over. Failure to comply will mandate a complete cleaning of the individual heads on the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Edwards System Technology (Sole Sourced)

2.2 APPROVED INSTALLERS

A. Systems Group – 800 E. 64th Ave. #17, Denver, CO (303) 298-7900
B. Convergint – 7330 S. Alton Way, Suite 12K, Centennial, CO (303) 932-0757

C. Meridian Fire and Security – 7173 S. Havana St Ste 400 Centennial CO, 80112 (303) 790-2520

D. Other Edward System Technology installers will be considered if they have successfully completed 3 similar projects (in size and complexity) in the past 5 years in the Denver Metro area. The installer must have a demonstrated ability to provide ongoing service to any system it installs. Alternate installers must be approved in writing by the University Project Manager through Facilities Operations 5 working day prior to Bidding on the project. Installers should be NICET certified.

2.3 MATERIALS, GENERAL

A. All equipment and materials used shall be standard components, regularly manufactured, and regularly utilized in the manufacturer's system.

B. All systems and components shall have been thoroughly tested and proven in actual use.

C. All equipment shall be listed and labeled by Underwriters Laboratories.

D. All sensors shall be of the intelligent type and shall mount on a common base. This base shall be incompatible with conventional detectors.

E. Where equipment of different manufacturers is used, such equipment shall be included under the required over-all UL system listing as a component of the integrated fire alarm system.

F. The system shall be designed to operate with unshielded wire, to the maximum practicable extent. Shielded wire may be used. FO cable shall be utilized, as required or as indicated by the design documents.

G. FACP's shall be provided with tamper switches on cabinet doors to protect against unauthorized access to internal devices. The panel shall provide commandable outputs, which can operate relays or logic level devices.

H. Memory data shall be contained in EEPROM non-volatile memory. If non-volatile battery-backed RAM provides memory, removal of the board shall not cause loss of memory contents.

I. The Fire Alarm annunciator panels shall be LCD types.

J. Site Specific Customizing Software:

1. General:
   a. Provide software and Programs with technical support and training for the university’s Facilities Operations staff during installation of system and completion.
   b. Alarm display shall include, as a minimum:
      1) Indication of alarm condition, i.e. ABNORMAL OFF, HI ALARM/ LO ALARM, analog value or status, and English group and point identification such as "SMOKE DETECTOR BUILDING “A” - 2ND FLOOR- ROOM 202".
      2) A discrete per point alarm action taking message, such as "CALL MAINTENANCE DEPT. EXT 5561", of up to 480 characters.
   c. System shall automatically transmit alarm and troubles to selectable university pagers via a commercial carrier such as "AT&T Wireless".
   d. The network routing properties for a panel's common controls determine which panels will respond when an operator presses the corresponding control command switch (Reset, Alarm Silence, Panel/Trouble Silence, Drill, Alternate Sensitivity) on the 3-LCD module.
Only the panels defined in the selected network routing group will respond to the command. Any building connected by a bridge or other structure shall annunciate to its opposite number(s) alarm, supervisory, and trouble conditions via single LEDs on its front panel.

2. Point summary reports:
   a. Point summary reports shall include the current value/status and condition.
   b. Trend reports shall allow the operator to randomly select logical arrays of points.
   c. Dynamic trends shall provide up to six points and show real time activity of the associated points.
   d. Alarm reports shall be automatically issued.
   e. A custom report capability shall be provided to allow the user to format reports of any mix of text, points with status/value and descriptors, and points with status/value only.

K. Fire Alarm System Devices:
1. General:
   a. Each device shall be assigned a unique address, 8 digit only Example (01020001). Address selection by jumpers is not acceptable. Devices which take their address from their position in the circuit are unacceptable. It is preferred that the address of the intelligent device be part of the device base rather than the device itself.
   b. Devices shall receive power and communication from the same pair of wires. For fault-tolerant circuits, any separate power wiring shall also be made fault-tolerant.
2. Analog Sensors (Photoelectric and Thermal):
   a. Each sensor shall contain an LED, which blinks each time it is scanned by the FACP. The sensor LED is to remain illuminated to indicate alarm. All sensors not visible from the corridor shall have a remote light mounted in the corridor as shown on the drawings.
   b. Each sensor shall be capable of being tested for alarm via command from the FACP or FACT. The values of the sensor shall be displayed at building FACP and FACT, and the University Police FACT.
3. Monitor Modules:
   a. The Monitor Module shall provide an addressable input for N.O. or N.C. contact devices such as manual stations, water-flow switches, sprinkler supervisory devices, door contacts, intrusion detectors, etc.
   b. The Module shall mount in a standard electrical box.
4. Control Modules:
   a. The Control Module shall provide an addressable output for a separately powered alarm-indicating circuit or for a control relay.
   b. The relay contacts shall be SPST (Form "C" rated at 2 amps at 28V DC).
   c. The module shall mount in a standard electrical box.
   d. Control voltage's connected to intelligent control relays shall not exceed 24VAC/24VDC. Isolation relays shall be used on control voltages on excess of 24VAC/24VDC.
5. Fault Isolator Module (only if approved by the University Project Manager):
   a. The Fault Isolator Module shall detect and isolate a short-circuited segment of a fire-alarm loop.
   b. Modules shall be placed on every floor to limit the number lost addressable devices in case of a short-circuit on the intelligent circuit.
6. Intelligent manual pull stations shall be double action is typical on campus, mounted on standard electrical box. a. For public places, use single action pull stations with "Stopper II" cover.
7. Magnetic door holders shall be wall- or floor-mount on a standard electrical box.
8. Linear beam smoke detectors shall have cross-zone capabilities and be provided where shown on the drawings. Detectors shall consist of a transmitter and receiver unit utilizing infrared light to detect smoke between the units. These detectors shall have discriminating circuitry to differentiate between actual smoke, momentary blockage of the beam, and long-term blockage.
   a. Contractor shall provide a weatherproof enclosure for each pair of devices, utilizing transparent panels to allow light transmission. Ensure range of detector is adequate to compensate for passage through this glass.
L. Other Devices:
   1. Speaker/Strobes:
      a. Strobes shall be synchronized.
      b. The speaker shall provide for minimum sound level of 95 dBA at 10 feet.
   2. Analog Air Duct Detectors:
      a. Duct detectors shall be mounted exterior of duct with air sampling tube. Program duct
detectors for supervisory indication only.
      b. Provide fire alarm remote light red LED, mounted on a standard plate fitted to a standard
electrical box. When device is not visible, labeled plate with the name of the device served.
      c. Fire alarm remote light/test switch combination shall be utilized for each duct detector. The
device shall have a red LED and two positions test switch mounted on a standard plate
fitted to a standard electrical box. Plates shall be labeled with the name of the equipment
served.
   5. Sprinkler Pre-action Solenoid and Deluge Valves: Installed under Division 21
   8. Relays provide addressable control and/or monitor module for each device indicated in paragraphs
P. 3, 4, 5, 6 And 7 above. Include wiring to the device and to the fire alarm loop as required.
   9. Provide control relays as required to accomplish functions such as fan shutdown, damper
positioning, door release, etc.
   10. Fire/Smoke dampers and smoke dampers will be provided under Division 23. The 24V wiring,
including low voltage transformer P.E. switch, will be provided under Division 23. The 120V AC
wiring will be provided under this section.
   11. Voice Evacuation Speaker/Strobe units shall be UL listed for use in voice evacuation systems.
Audible and visual indications shall operate independently or in unison.
   12. Animal Care Facilities
      a. Provide “Silentone” horns or approved equal throughout all animal care facilities. Provide
red lensed strobe in animal holding rooms.
      b. Provide speakers in the office areas of the animal facility.

M. Voice Evacuation System:
   1. The Contractor shall provide all work required for installation of a Voice Evacuation System for
the buildings indicated by the drawings. Scope of this Contractor's work will be as described by this
section of the specifications and as shown on the drawings.
   2. Buildings that are defined as high rise shall have the following: An Audible Alarm on the floor
where that event is detected and a general message to all other floors stating, “A fire Alarm has
been detected on (indicate floor number). Remain alert and evacuate if there are indications of fire.
O. Voice Evacuation System:
   1. The Contractor shall provide all work required for installation of a Voice Evacuation System for the buildings indicated by the drawings. Scope of this Contractor's work will be as described by this section of the specifications and as shown on the drawings.
   2. Buildings that are defined as high rise shall have the following: An Audible Alarm on the floor where that event is detected and a general message to all other floors stating, “A fire Alarm has been detected on (indicate floor number). Remain alert and evacuate if there are indications of fire.

   If no danger is noted, you may await further instruction. Elevators have been recalled to level 1 (or alternate floor if the fire alarm is on level 1) until the fire alarm is over.”

   3. Fire Alarm Voice Evacuation Panel (FVEP):
      a. The FVEP shall be located in conjunction with the FACP and shall provide evacuation signals, pre-recorded fire alarm messages, and one-way communication (paging) on a selective.
      b. FVEP equipment shall include the following:
         1) Voice paging, hand-held, push-to-talk microphone with dynamic noise canceling. Frequency response shall be flat within $+3$ dB from 200 to 5000 Hz.
         2) Zone paging selector switches and LED's, with one selector switch and two LED's provided for each speaker zone.
         3) "Manual Fire Evacuation Tone" switch and LED.
         4) "Silencing" fire evacuation tones (self-restoring switch) and LED.
         5) "Pre-recorded Message" switch and LED.
         6) "All Call", switch and LED, with the switch enabling the operator to simultaneously page all speaker zones on both risers.
         7) Reset switch.
         8) Lamp test switch.
         9) "Page" LED, which will light when the paging microphone is used.
        10) The FVEP shall also be equipped with LED's to indicate trouble conditions for the following:
            a) Each individual speaker zone.
            b) Amplifier, preamplifier, fire tone, pre-recorded messages, and voices paging.
        11) All switches and LED's shall be clearly identified with engraved labels.
        12) Each group of LED's shall have distinctive colors, such as:
            a) Fire Tone - Red
            b) Silence - Yellow c) Page - Green
d) Trouble - Yellow
e) Pre-recorded Message - Red
   c. The fire evacuation signal shall be applied to any specific zone automatically from the FACP or FACT, or shall be selected manually by the speaker zone switch.

   4. FVEP Audio Cabinet:
      a. 100% redundant tone generators, preamplifiers, and amplifiers shall be provided.
      b. The audio trunk shall be electronically supervised and shall be automatic switchover from one audio signal path to the other.
      c. Each amplifier module shall be provided with two 40-watt amplifiers, and shall power a minimum of 8 speaker zones.
      d. Pre-recorded message shall be programmed and recorded in a memory chip. Tape cassette players are not acceptable.
      e. The FVEP audio cabinet shall be capable of remote "All Page" activation via local microphone from the University Police Station. The system shall allow the selection of individual building or "All" buildings for "Disaster Messages".
      f. Provide capability of testing and adjusting audio amplifier outputs. Provide test switch at the FACP.
P. Spare Parts: Refer to Section 01 78 46 – Extra Stock

Materials. PART 3 - EXECUTION

3.1 INSTALLATION – FIRE ALARM

A. Fire Alarm layouts:
   1. General:
      a. Provide a fire alarm system for each building.
         1) Actual detection required per building shall be determined by National codes, Local codes and the university CBO, whichever is more stringent.
      b. Provide shunt trip circuit breaker for connection to elevators with sprinkler red shafts.
   2. Regardless of building occupancy rating, the following areas shall be provided with detection:
      a. Laboratories
      b. Electrical Rooms
      c. Mechanical Rooms
      d. Telecommunications
      Rooms e. Data Centers
      f. Dedicated Storage
      Rooms g. Kitchens
   3. In general, the following type of detection shall be provided in each type of room:
      a. Photoelectric Smoke Detection:
         1) Electrical/Telecommunication Rooms
         2) Office Corridors (except where sprinkled)
         3) Offices (except where sprinkled)
         4) Laboratories
         5) Mechanical Ducts
         6) Elevator Shafts/Machine Rooms
         7) Dedicated Storage Rooms
         8) Linear Equipment
      Rooms b. Thermal Detection:
         1) Restrooms
         2) Mechanical Rooms
         3) Kitchens/Break rooms
         4) Environmental Services (Janitor) Rooms
         5) Elevator Shafts/Machine Rooms
         6) Generator Rooms
         7) Autoclaves c.
      Flame Detection:
         1) Generator Rooms
   4. Provide control module at each access control panel for interface with access control system.

B. Installation shall be supervised and tested by the manufacturer of the system equipment.

C. Low Voltage/Wire and Cable: All LV/W&C shall be run in conduit in floors, walls and non accessible spaces. In hallways, LVW/C can be run in bridle rings attached to the common telecom and other low voltage system cable tray. LV/W&C must be run in a conduit sleeve, minimum 2” dia. with plastic bushings, from the point it leaves the bridle ring on the cable tray to the interior side of a room. Once the LV/W&C enters the room it can be supported from bridle rings or j-hooks. Wiring shall comply with Division 27 and approved NEC.

FIRE DETECTION AND ALARM
D. Low Voltage/Wire and Cable and Hallway Devices: LV/W&C running from the cable tray to devices in the hallway shall be protected by plenum rated flexible sleeving or flexible metal conduit. LV/W&C in sleeving or flexible metal conduit shall be supported per NEC and installed with UL approved connectors and plastic bushings on both ends.

E. Outlet pull and junction boxes shall be painted red on the exterior. F. Devices: Locate devices per ADA standards

G. In construction areas where there is existing equipment, the equipment must be protected during construction and the devices taken off line to eliminate false alarms. All devices associated with modifications to an existing.

H. Contractor is liable for damage. The university must be notified at the completion of each project to ensure that the system is returned to normal.

I. If room numbers are changed or new room numbers established, the University Project Manager must be notified before implementation so that the system can be re-programmed and is accurate in the event of an alarm.

J. All devices mounted in ceiling tile to be supported by T-bar hanger bracket and appropriate box. Plaster ring is not acceptable.

K. Labeling:
   1. Observe the university fire alarm color code guide.
   2. Label each splice with correct information.
   3. Label each initiating device with correct device address. Use Kroy labeler or equal.
   4. Final, correct university room numbers (not design/construction room numbers) must be provided for correct programming.
   5. All detectors to have factory dust covers installed until after the final inspection and clean up is complete.
   6. All duct detectors to have individual remote LED/test stations installed. Mount at 6'-0" AFF in main corridor adjacent to area served. Label as directed by the University Project Manager.
   7. All shielded wiring to be bonded together at each device and insulated from contact with the conduit or box.
   8. All equipment and associated wiring removed from service will be returned to the University Project Manager for proper disposal.
   9. Avoid locating detectors above countertops and/or shelving.
   10. Locate detectors at least eight feet from supply or return air diffusers.
   11. Use fixed heat detectors near autoclaves and steam sterilizers.
   12. Mount remote lights for room detectors above door to corridor, centered.

L. Construction Requirements:
   1. Integrity of Structure: Do not drill or pierce structural members without prior approval from the University Project Manager and Structural Engineer.
   2. Penetration of Walls, Etc.: Fire caulk or seal all penetrations made through walls, floors, and ceilings around the conduit. Maintain the integrity of fire ratings within the structure. Where visible, paint to match surface.
   3. Wherever possible, install conduits and raceways in a concealed manner, except at surface-mounted cabinets.
   4. Access to Existing Facilities: Install all conduit and pull boxes to maintain or provide access
to existing valves; covers to existing pull boxes; wire ways or access doors; electrical outlets; switches; motors, etc.
5. Support bridle rings/"J" Hooks independently from structure, may have separate point of attachment to cable tray.
6. No other wiring or systems to be installed with fire alarm.

M. Prior to start of construction, disable existing fire alarm devices, as necessary. A minimum of two working days notice, prior to construction, shall be coordinated through the University Project Manager.

3.2 TESTING, CLEANING AND CERTIFICATION

A. When installation is complete, system shall be tested in accordance with NFPA72 requirements. A representative of the system manufacturer shall submit a written report of the findings to the A/E with copy of to the FD. System testing shall include, at the least, verifying the following:
1. The functional operation of each re-settable initiating device (manual stations, detectors, etc.) and circuit.
2. All notification appliances shall be tested for a minimum of ten minutes under normal alarm conditions.

H. Contractor is liable for damage. The university must be notified at the completion of each project to ensure that the system is returned to normal.

I. If room numbers are changed or new room numbers established, the University Project Manager must be notified before implementation so that the system can be re-programmed and is accurate in the event of an alarm.

J. All devices mounted in ceiling tile to be supported by T-bar hanger bracket and appropriate box. Plaster ring is not acceptable.

K. Labeling:
1. Observe the university fire alarm color code guide.
2. Label each splice with correct information.
3. Label each initiating device with correct device address. Use Kroy labeler or equal.
4. Final, correct university room numbers (not design/construction room numbers) must be provided for correct programming.
5. All detectors to have factory dust covers installed until after the final inspection and clean up is complete.
6. All duct detectors to have individual remote LED/test stations installed. Mount at 6’-0” AFF in main corridor adjacent to area served. Label as directed by the University Project Manager.
7. All shielded wiring to be bonded together at each device and insulated from contact with the conduit or box.
8. All equipment and associated wiring removed from service will be returned to the University Project Manager for proper disposal.
9. Avoid locating detectors above countertops and/or shelving.
10. Locate detectors at least eight feet from supply or return air diffusers.
11. Use fixed heat detectors near autoclaves and steam sterilizers.
12. Mount remote lights for room detectors above door to corridor, centered.

L. Construction Requirements:
1. Integrity of Structure: Do not drill or pierce structural members without prior approval from the University Project Manager and Structural
2. Penetration of Walls, Etc.: Fire caulks or seal all penetrations made through walls, floors, and ceilings around the conduit. Maintain the integrity of fire ratings within the structure. Where visible, paint to match surface.
3. Wherever possible, install conduits and raceways in a concealed manner, except at surface-mounted cabinets.
4. Access to Existing Facilities: Install all conduit and pull boxes to maintain or provide access to existing valves; covers to existing pull boxes; wire ways or access doors; electrical outlets; switches; motors, etc.
5. Support bridle rings/“J” Hooks independently from structure, may have separate point of attachment to cable tray.
6. No other wiring or systems to be installed with fire alarm.

M. Prior to start of construction, disable existing fire alarm devices, as necessary. A minimum of two working days notice, prior to construction, shall be coordinated through the University Project Manager.

3.2 TESTING, CLEANING AND CERTIFICATION

A. When installation is complete, system shall be tested in accordance with NFPA72 requirements. A representative of the system manufacturer shall submit a written report of the findings to the A/E with copy of to the FD. System testing shall include, at the least, verifying the following:
1. The functional operation of each re-settable initiating device (manual stations, detectors, etc.) and circuit.
2. All notification appliances shall be tested for a minimum of ten minutes under normal alarm conditions.
3. The functional operation of each and every alarm device and circuit.
4. The functional operation of each monitored device circuit.
5. The functional operation of each control circuit, including fan controls.
6. The supervision functions of each initiating, indicating, monitoring, control and supply circuit.
7. Control station automatic signaling.
8. That all software protocol, access codes and operation instructions have been supplied.
9. All installed or modified fire alarm systems for remodels or new projects shall be tested and certified by a Factory Representative. Upon a system test completion a “Letter of Certification” shall be issued to the university.

B. All testing and verifications shall be conducted in the presence of the university Facilities Operations Fire and Safety personnel.

C. There shall be an operational test by the FD.

3.3 COMMISSIONING (DEMONSTRATION)

A. The equipment supplier shall provide a minimum of 8 hours of system training for the university Facilities Operations personnel training for each new system.

END OF SECTION 28 31 00
SECTION 31 10 00 - SITE CLEARING AND SITE GRADING

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Trash Removal:
      a. Remove all trash, sand, gravel, road base, concrete, and trench material.

B. Performance Requirements
   1. Top Soil:
      a. Coordinate with the University Project Manager for stripping and separate stockpiling for
         replacement around the building at the completion of the job, and/or disposal.
      b. Strip top soil to a depth of approximately 6 to 8 inches from all areas to be graded, excavated or filled.
      c. Remove debris, staging, tracking pads, and other items of construction from soil to a
         maximum of 18” and recondition sub grade to a condition similar to original site
         conditions.

1.2 QUALITY ASSURANCE

A. Testing Laboratory Qualifications:
   1. Hazardous Waste Removal:
      a. Submit plans and procedures for removal of hazardous waste to the University Project
         Manager for approval by the University Environmental Health and Safety (EHS).

B. Regulatory Requirements:
   1. Asbestos-Contaminated Soil Management, Standard Operating Procedure Document, Version 1,
      February 26, 2010.
      a. Refer to Section 02 81 00 – Transportation/Disposal of Hazardous Material, Part 4.

C. Site Water Quality:
   1. Obtain related permits prior to starting work and provide copy of plan and permit to the University
      Project Manager.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 31 10 00
SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 REFERENCES

   1. Refer to Section 02 81 00 – Transportation/Disposal of Hazardous Material, Part 4.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Performance Requirements
   1. Backfilling:
      a. Backfill excavations as promptly as work permits, but not until completion of inspection, testing, approval, and location recording of underground utilities.
      b. Concrete tailings, sand, gravel and other debris are not permitted in trenches.
      c. Consult the University Project Manager immediately for direction with uncharted or incorrectly charted piping or other utilities encountered during excavation. Cooperate with the University Project Manager in keeping respective services and facilities in operation. Repair damaged utilities to the satisfaction of the University Project Manager.
   2. Excavations:
      a. Surround all excavations exceeding 6 ft in depth with a 6 feet high chain link fence system.
      b. Provide an Environmental Health and Safety (EHS) trained spotter on site for identifying asbestos contaminated soil.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 31 20 00
SECTION 32 00 00 - EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Provide splash blocks and rip rap at all downspouts and fire pump outlets in landscape areas. Redirect water to prevent damage to landscape and avoid water freezing on sidewalks.
   2. Provide Bus Shelters as required;
      a. Color: Stormcloud, RAL 7022

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 32 00 00
SECTION 32 10 00 - BASES, BALLASTS, AND PAVING

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Sidewalks:
      a. Maintain 5 foot minimum clearance from all existing trees where possible.
      b. Provide 6 feet minimum radius turns to accommodate turning radius of tractors used for snow removal.
      c. Develop joint pattern to:
         1) Prevent cracking from expansion and contraction.
         2) Compliment joint pattern in adjacent surfaces.
         3) Saw cut joints are accepted as an alternative method to tooled joints.
      d. Provide a medium broom finish perpendicular to travel direction.
      e. Detectable Warnings: In accordance with local jurisdiction.
      f. Take precaution to avoid puncturing existing irrigation lines with concrete form materials. The contractor will cover all repair costs.
   2. Dumpster Pads:
      a. Determine location of pads for dumpsters with the University Facility Operations, and the campus Architect through the University Project Manager.
      b. Provide minimum pad size of 8 feet x 8 feet to a maximum of 24 feet x 14 feet and a minimum of 6 inches thick.
   3. Bicycle Pads:
      a. Coordinate with the University Project Manager for bicycle pad requirements.
   4. Wheelchair Ramps:
      a. All entrances must be handicap accessible.
   5. Asphalt Parking Lots and Driveways:
      a. If an aggregate base course is recommended by the project’s pavement design, construct the base course utilizing CDOT Class 6 aggregate to the depth specified in the pavement design.
   6. Transformer Pads:
      a. Locate building electrical transformers outside of the building. Coordinate project specific locations with the University Project Manager.
   7. Parking:
      a. Provide striping for stalls 8’-6” x 20’-0” at non-handicap designated stalls.
      b. Provide minimum 20’-0” wide drive lanes.
      c. Wheel stops are not acceptable in parking lots.
      d. Designate ADA parking stalls with painted symbol and a sign.
      e. Provide reflective signage.
      f. Provide banner signs in parking lots where applicable.
         1) 24” wide x 60” long, double sided with 3” pole pockets, heavy duty brackets, and pole mounts on top and bottom.
   8. Monument Sign:
      a. Refer to Part 2.18 – Campus Signage Guidelines

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sidewalks (6 feet wide and over):
   1. Concrete: 6 inches thick, 4000 psi
   2. Reinforcing: Fiber-mesh
B. Sidewalks (less than 6 feet wide):
   1. Concrete: 4 inches thick, 4000 psi
   2. Reinforcing: Fiber-mesh

C. Dumpster Pads:
   1. Concrete: 6 inches thick, 4000 psi
   2. Reinforcing: Fiber-mesh

D. Bollards:
   1. Manufactured, manually removable bollard
      a. 36 in (91.4cm) high x 4-1/3 in (11cm) base diameter, 62 lbs (28 kg)
      b. Color: RAL 7022
   2. Receiver:
      a. Galvanized ground sleeve with stainless steel locking cover; flush mount when bollard removed.

E. Pavement Markings
   1. Pavement-Marking Paint: Alkyd Traffic Marking Paint
      a. Color: White
      b. Non-Reflective
      c. VOC Content: Pavement-marking paints shall have a VOC content of 150 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 32 10 00
SECTION 32 84 00 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. General Information
   1. Design Requirements
      a. Provide systems clocks in various locations to control watering schedules. Coordinate
         locations with the University.
      b. Provide automatic rain shutoff devices at all new irrigation.
      c. Separately meter all sprinkler irrigation systems from the building. Provide pulse output to
         Building Automation System at all meters.
      d. Verify locations of underground utilities including the existing irrigation system
         components.
      e. Puddle backfilling of new trenches in landscaped areas. Provide adequate compacted
         backfill under pavement.
      f. Pulse Transmitters:
         1) Provide RTR pulse transmitters with all Badger irrigation water meters.
         2) Provide TRICON/E3 pulse transmitter with all Neptune irrigation water meters.
         3) Provide Sensus pulse transmitter with all Sensus irrigation water meters.
   2. Performance Requirements
      a. Any kinked or damaged pipe is not acceptable.
      b. Turn over existing irrigation controllers, sprinklers and valves to the University unless
         otherwise instructed.

B. Remote Solenoid Control Valves:
   1. Design Requirements
      a. Provide a minimum of 4 inches between bottom of box lid and highest part of valve and
         between bottom of box and piping. Provide a minimum of 4 to 6 bricks to support the
         bottom side of box. Hand tamp ground underneath valve boxes.
      b. Provide all RCVs of the same brand.
      c. On City of Aurora water system, Use Irritrol Ultra Flow plastic.
      d. Remove and replace existing galvanized fittings with PVC whenever possible.
      e. Flush each RCV zone with sprinkler heads removed.

C. Sprinkler Heads:
   1. Design Requirements
      a. Include models with 12 different size nozzles per head, gear driven and sealed in oil, strip
         proof gears, vandalism resistant, dirty water screen, small surface area and fully
         interchangeable.
      b. Located heads a minimum of 1 inch from walk and 3 inches from building or vertical
         surface. Place top of heads exactly at finished grade. Where heads are next to walks or
         curbs, place top of head flush with top of sidewalk or curb.
      c. Firmly tamp under and around heads so as to be exactly straight up and down.
      d. Provide 8 to 12 inches of swing pipe; Do not to exceed 24 inches.
      e. See Diagram in Part 4 – Illustrations.

D. Electrical Control System:
   1. Design Requirements:
      a. Coordinate control system electrical power supply with the electrical engineer.
      b. Provide lawn sprinkler cabinet in the grounds closet (if provided), the mechanical room, or
         other services area space. Provide electrical service (110V) at this location with conduit
         large enough to contain the valve control wires to the outside.
c. When extending existing irrigation systems, the University Project Manager will determine replacement of the control wire from a satellite controller and to a solenoid valve. The University Grounds will determine the exact site locations of the electrical control system. Test for positive radio communication prior to the installation of the satellite controllers.

d. Provide lightning protection with a copper-clad grounding rod driven into the soil 8 feet deep. A single rod may be used for grouped control units. Connect controller to grounding rod with AWG No. 10 solid conductor copper wire. Secure wire to grounding rod with brass or bronze clamp. If rod is buried adjacent to the controller enclosure, locate the connection in a separate valve box.

e. Attach wire markers to the ends of control wires inside the controller unit housing. Label wires with an identification number which consists of the name and station number of the existing controller to which the control wire had been previously connected.

f. Bundle control wires where two or more are in the same trench at a minimum of 10 foot intervals.

g. Control wiring may be pulled into the soil utilizing a vibratory plow device specifically manufactured for pipe pulling. Minimum burial depth equals 12 inches.

h. Provide a 24 inch excess length of wire in an 8 inch diameter loop at each 90 degree change of direction, at both ends of sleeves and at 100 foot intervals along continuous runs of wiring. Do not tie wiring loop. Coil 24 inch length of wire within each remote control valve box.

i. Install only one control valve on each control wire.

j. Pre-number or label control wires with indelible non-fading ink, made of permanent, non-fading material.

k. Provide wire from satellite controller unit to each remote control valve for new construction using AWG No. 14 solid copper, Type UF cable, UL approved for direct underground burial or multi-strand type UF irrigation cable no smaller than 18 gauge.

l. All wiring sizing must conform to the manufacturers recommendations on voltage losses of solenoid valves being used and must not exceed these specifications.

m. Provides wires with the same color over its entire length. Provide white for common ground wire.

n. Crimp solder splices and seal with waterproof sealant. Provide plastic wire connectors consisting of two pieces: one piece which snap locks into the other. Provide a copper crimp sleeve with a connector. All wiring splices that are direct buried must be done with "3M" D by wire splice kits.

2. Performance Requirements


b. Fittings: Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784.

E. Sleeking:

1. Design Requirements

a. Install separate sleeves beneath paved areas to route each run of irrigation wiring bundle.

b. All sleeves under pavement must be bedded in sand with a minimum of 6 inches above and below the sleeve.

c. Install only one irrigation pipe per sleeve.

d. Install sleeking at a depth which permits the encased wiring to remain at the specified burial depth.

e. Extend sleeve ends six inches beyond the edge of the paved surface. During construction, cover sleeve ends and mark with stakes. Mark concrete with a chiseled "X" at sleeve end locations.

f. Bore through obstructions which cannot be removed rather than alter the route. Employ equipment and methods designed for horizontal boring.

g. Cut and patch roadways which must be crossed. Replacement asphalt and subgrade shall match existing conditions. All sleeves under pavement shall be embedded in sand with a 6 inch cover under and above sleeve.
h. Provide PVC Class 200 pipe with solvent welded joints for sleeving material beneath pedestrian pavements, drives, and streets.

i. Provide sleeving diameter a minimum of twice that of the pipe and wiring bundle, whichever is greater. Provide a minimum diameter of 2 inches for sleeves for wiring.

F. Piping:
   1. Design Requirements
      a. Locate all pressurized pipe between 14 inches and 18 inches deep.
      b. Locate all non-pressurized poly pipe shall between 8 to 12 inches deep.
      c. Locate pressurized and non-pressurized pipe underneath roads at a minimum of 18 inches deep.
      d. Map and document any changes to new or existing piping indicating size, type and location of pipe.
      e. Provide concrete thrust blocks on all pressurized pipe 2 inches and larger. Base selection on 60 psig static system pressure.
      f. Provide lateral branch lines of poly pipe rated at 100 psig NSF for 3/4 and 1 inch sizes. Provide poly pipe at larger branch lines and main trunk lines. All poly pipe of 1-1/4 inches and larger must be 80 psig NSF grade.
      g. All poly pipe fittings must be plastic barbed, designed specifically for underground irrigation practices. Provide schedule 40 PVC fittings, with solvent weld on all sizes 3 inches and smaller and tight fittings on all sizes 3 inches and larger. Provide appropriate thrust blocking at ring tight.
      h. Double clamp all 1-1/4 inch and larger insert fittings; smaller poly pipe may be single clamped with screw or pinch clamps.

1.2 SUBMITTALS
   A. Record Drawings: Record all alterations with accurate reference dimensions, measured from at least two permanent reference points, for each controller or control unit, each sleeve end, each stub-out for future wiring connections, and other irrigation components enclosed within a valve box.

1.3 WARRANTY
   A. Provide a one year warranty including blow out and turn on. The warranty shall include, but not be limited to, fill and repair depressions and restoration of landscape or structural damaged by the settlement of irrigation trenches or excavations. Repairs shall be made within seven days of notification from the University Project Manager.

   B. Provide a 2 year minimum warranty for all sprinkler heads.

PART 2 - PRODUCTS

2.1 MATERIALS
   A. Acceptable Manufacturers: Subject to compliance with requirements, provide the following products or comparable products:
      1. Electric Valves:
         a. Preferred: Irritrol Ultraflow 700 Series - .75 - 1 - 1.50 - 2 - in.
         b. Rain Bird 100-DV/100-DV-F - .75 - 1 - 1.50 - 2 - in.
      2. Brass Gate Valves (all with cross handles), Size .50 to 3 inches:
         a. Matco 515T (Treaded)
         b. Matco 515C (Solder)
      3. Forged Brass Ball Valves, Standard/Full or Full Port Drainable:
         a. Matco 752T - 752C
         b. Matco 754T - 754C
4. Automatic Drain Valves:
   a. King Drains
   b. Imperial
   c. Rain Bird

5. Valves Cover Boxes:
   a. Carson Boxes: any model size as needed
   b. Ametex Boxes: any model size as needed

6. Controllers:
   a. Rain Bird

7. Pop-up Spray Sprinkler:
   a. Rain Bird 1800 Series Size 1802 to 1812 Regular, S.A.M. or Pressure Regulating
   b. Hunter S-type 4 inch
   c. Spray Nozzles, as needed (plastic/brass)

8. Rotor Pop-up Sprinkler Mini-Paw, Maxi-Paw:
   a. Hunter I-20
   b. Hunter I-25

9. Flex Swing Pipe:
   a. Hardie (Super Blue)
   b. Rain Bird (20/SP-100)

10. Clamps for Poly Pipe:
    a. Crimp Clamp (size .50 to 1 inch)
    b. Murray Worm Gear Clamp (size .50 to 3 inch) 100% stainless steel

11. Wire Connectors:
    a. 3M DBY/DBR Direct Bury Connector
    b. Rain Bird ST-03 Gray/PT-S5 Snap-Tite
    c. Fixed Spring Wire Connectors

12. Quick Coupling Valves:
    a. 3 NP/33 DNP/5NP/44NP (non-portable)
    b. 3RD/33DRC/5RC/44RC Quick Coupling Valves

13. Drip Irrigation:
    a. Rain Bird Underground Pressure Regulator HMB-20 and 25
    b. Rain Bird Y-filters RBY-075-RBY-100
    c. Hardies Y-filters

14. Drip Tubing:
    a. Blue Stripe
    b. Lasco
    c. Pepco

15. Drip Emitters:
    a. Rain Bird
    b. Salco
    a. Agrifim

16. Irrigation Water Meters:
    a. Badger (Preferred)
       1) Recordall Disc Series up to 2"
       2) Turbo Series over 2"
    b. Neptune
       1) T-10 up to 2"
       2) HP Turbine over 2"
    c. Sensus
       1) SR II up to 2"
       2) Turbo over 2"

2.2 MATERIALS

A. Copper Tube:
1. Type K
2. Type L
3. Type M
4. Copper fitting (all)

B. Ultra-Clear Flexible Pipe:
1. .50 to 2 inch (125 psi) NSF
2. .50 to 2 inch (100 psi) NSF
3. .50 to 2 inch (80 psi) NSF

C. PVC Pipe:
1. 1 to 6 inch (class 200)
2. 1 to 6 inch (class 160)

D. Insert Fittings (PVC and Nylon):
1. PVC (Schedule 80)
2. PVC (Schedule 40)

E. Weld-on Plastic Pipe Cement (PVC only):
1. #725 cement P70 primer
2. #711 cement P70 primer
3. #727 cement P70 primer

F. Teflon Seal Thread Tape and Paste:
1. STT - 12 x 600 1/2 x 600' Tape
2. STT - 34 x 520 3/4 x 600' Tape
3. STT - 1 x 520 1 x 500' Tape

G. Wire Solder:
1. Silver and Safe Flow Silver
2. Silver Bearing Solder: 96% tin, 4% silver
3. 95/5; 95% tin, 5% antimony

H. Sprinkler Control Wire “UL” Listed:
1. #18-4 to #18-12 PJ Thermo Multi-conductor Spool
2. 14-UF Single Conductor Reels
3. 12-UF Single Conductor Reels

I. Tools and Spare Parts: Refer to Section 01 78 46 – Extra Stock Materials.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. System Damage:
1. Immediately repair any main line damage.
2. Contact the University Project Manager in the event of damage to poly lines or sprinklers to repair damage promptly and in the proper sequence. Stop work and notify the University Project Manager if asbestos irrigation pipe is damaged.
   a. Immediately upon cutting through the irrigation line, cut and tape both ends such that dirt and debris cannot get into the lines.
   b. Backfill and tamp, or puddle up to the level of irrigation line that is to be repaired and notify the University Project Manager. After repair has been completed, backfill to grade but do not tamp directly on top of irrigation line.
B. Warning Tape:
   1. Bury warning tape six inches deep on top of control wiring. Provide inert plastic film tape highly resistant to alkalis, acids, or other destructive chemical components likely to be encountered in soils. Provide tape that is three inches wide, colored yellow and imprinted with "CAUTION: BURIED ELECTRIC LINE BELOW."

3.2 TESTING, CLEANING, AND CERTIFICATION

A. Electrical:
   1. Test for leaks to ground per manufacturer's recommendations. Test wires, underground splices or appurtenances and replace defective items. Repeat tests after replacement and approval by Grounds through the University Project Manager.
PART 4 - ILLUSTRATIONS

4.1 SPRINKLER HEAD PIPING DETAILS

END OF SECTION 32 84 00
SECTION 32 92 00 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Provide type of sod or seed for repair or replacement of existing turf to match the surrounding turf.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Sod
   1. Do not use sod left out for more than 24 hours without approval from the University Project Manager.
   2. Keep sod in rolls moist and protected from exposure to sun, wind and heat.
   3. Protect all sod transported in open vehicles for a distance of more than 25 miles.
   4. Notify the University Project Manager of all sources of sod 3 business days in advance of cutting.

B. Seed
   1. Deliver seed in original sealed, labeled, and undamaged containers.

1.3 WARRANTY

1. Provide warranty for sod and seed for a period of one year from the date of final completion. The warranty period begins anew for each required replacement of sod.

   2. Warranty Condition:
      a. Resod or reseed all areas when sod or seed is no longer in a satisfactory growing condition as determined by the A/E for the entire warranty period.
      a. Replacement will not be allowed in any season determined unfavorable for sodding or seeding.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sod:
   1. Provide new sod of uniform density, color, and texture, and strongly rooted.
   2. All sod: equivalent of a 90% Turf-type Tall Fescue (2 varieties), 10% Improved Kentucky Bluegrass sod or as approved by The University Facility Operations through the University Project Manager.
   3. Provide sod with a vigorous and healthy root system that has been regularly watered, mowed, fertilized and sprayed for weeds in the sod nursery.
   4. Provide each piece of sod free of objectionable weeds.
   5. Provide sod that will not tear, break or crumble during the handling and placing of the sod.
   6. Unless short and smooth, clip the grass with a lawn mower to a height of two inches before it is lifted. Cut the sod evenly not more than one inch thick and cut in strips approximately eighteen inches in width.

B. Seed:
   1. Grass seed to be fresh, clean, dry, new seed proportioned by weight as follows:
       a. Equivalent of a 90% Turf-type Tall Fescue (2 varieties), 10% Improved Kentucky Bluegrass seed or as approved by The University Facility Operations through the University Project Manager.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Sodding and Seeding Season:
   1. Sod or seed only after April 1 and before October 1 unless approved by the A/E.
   2. Sod or seed only when weather and soil conditions permit in accordance with locally accepted practice.

B. Lawn Area Preparation:
   1. Spread well rotted cow manure over the surface of the ground of the areas to be covered at the minimum rate of three cubic yards per thousand square feet. Thoroughly till the areas to a depth of from a minimum of 4 inches to a maximum of 6 inches until no manure appears on the surface.
   2. Remove all sticks, stones and other debris appearing on the surface or larger than 1 inch in any dimension. Grade the entire surface so that no unevenness appears. Finish grade in accordance to grading plan and remove any high or low spots to obtain an even surface.

C. Lawn Installation:
   1. Verify areas to be sodded or seeded are smooth before any sodding or seeding is to be done. If slopes are steeper than 2:1, lightly and sufficiently water the bed.
   2. Lay sod by staggering joints. On any slopes, run the sod perpendicular to the slope. When in position, water the sod, then roll and/or tamp into contact with the soil, so that no open joints are apparent. After laying the sod, fertilize with a commercial fertilizer 20-20-10 at the rate of ten pounds per thousand square feet.
   3. Drill seed areas requiring seeding. Sow seed at a rate of 5-6 lbs/1000 sf.
   4. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly to form a continuous blanket 1 ½ inches in loose depth over seeded areas. Crimp mulch.

D. Watering:
   1. Directly following installation, water the sod lightly and sufficiently to a depth of 4 inches with care so that no erosion takes place and so that no gullies are formed.
   2. Water sod and seed in early morning and afternoon for at least five successive days after laying to establish the lawn as determined by the University Project Manager. During hot weather, keep the sod moist and do not allow to dry out for a minimum of three weeks after installation.

E. Maintenance of Turf:
   1. General: Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as aerating, rolling, regrading and resodding as necessary to establish a smooth, acceptable lawn, free of eroded or bare areas or as directed by the Architect.
      a. Overwatering of lawn, which causes stress to trees, is not allowed.
   2. Maintenance Period: Begin maintenance immediately after sodding or seeding. Maintain lawn areas until the end of the Warranty period. If sodding occurs in autumn and maintenance has not been performed, or if work was not yet acceptable at the end of autumn growing season (October 1), continue maintenance the following spring beginning April 1 (or sooner, weather permitting) and continue to the end of the warranty period.
   3. Mowing and Trimming: Mow and trim around tress (keeping mulch in saucers and beds), walls, fences, etc., maintaining turf at 2 – 2 3/4” height. Do not remove more than 33% of grass leaf in single mowing. Remove grass clippings from pavements areas.

END OF SECTION 32 92 00
### SECTION 32 93 00 - PLANTS

**PART 1 - GENERAL**

1.1 General Design Information:

A. Design Requirements
   1. Avoid using isolated islands or berms as they are labor intensive.
   2. Design in context with adjacent spaces.

B. Performance Requirements
   1. Protect existing landscape features, especially trees and shrubs.

1.2 Repair of Landscape or Irrigation System Damage:

A. Performance Requirements
   1. Include the cost of restoration to existing landscape for damage associated with construction in the bid proposal. Repairs include damage outside of construction zones if damage results from some effect of project such as rerouting of pedestrian traffic across a grassy area in lieu of a previous sidewalk path.
   2. At the contractor’s option, restoration work may be completed by the University through the University Project Manager or by a prequalified Landscape Contractor. Competitive bidding between the University and Landscape Contractors is not permitted.
   3. Establish the extent of restoration work in the following manner:
      a. Prior to construction, survey the site with the University Project Manager, A/E, and Contractor.
      b. Document the initial condition through mutual agreement, written description, sketches and/or photographs.
      c. After construction, survey the site with the same group and document the final condition through the same procedure.
   4. Include restoration work in the Construction Documents and encompass intermediate or temporary repairs. Temporary repairs may be necessary to keep irrigation systems active. Inactive irrigation systems may result in additional damage to turf areas which may require restoration work.

1.3 Layout of New Trees:

A. Design Requirements
   1. The use of street trees is encouraged in all designs. Coordinate with the University Campus Architect through the University Project Manager.
   2. Provide a minimum 3 feet diameter mulch area around all trees. Cover with shredded cedar mulch.
   3. Do not plant trees above underground utilities. The following table identifies the minimum and recommended distances from trees to utilities and other site items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Distance (feet)</th>
<th>Preferred Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curbs</td>
<td>2.5 CE</td>
<td>3-5 CE</td>
</tr>
<tr>
<td>Sidewalks</td>
<td>2.5 CE</td>
<td>3-5 CE</td>
</tr>
<tr>
<td>Electric Buried Cable</td>
<td>4 CC</td>
<td>5-6 CC</td>
</tr>
<tr>
<td>Water Lines</td>
<td>6 CC</td>
<td>7-8 CC</td>
</tr>
<tr>
<td>Sewer Lines</td>
<td>10 CC</td>
<td>15+ CC</td>
</tr>
<tr>
<td>Steam/Condensate Lines</td>
<td>10 CC</td>
<td>15+ CC</td>
</tr>
<tr>
<td>Gas Lines</td>
<td>4 CC</td>
<td>5-6 CC</td>
</tr>
<tr>
<td>Street Lights-Shade Trees</td>
<td>40 CC</td>
<td></td>
</tr>
</tbody>
</table>
1.4 Landscape Requirements:

A. Design Requirements
1. Provide a weed control blanket underlay of polyester nylon mesh at all planting beds. Do not use polypropylene.
2. Provide a minimum of three inches of depth of shredded cedar mulch in the shrub beds after setting.
3. Gravel or rock larger than 1” is prohibited.

1.5 Protection and Preservation of Existing Trees:

A. Design Requirements
1. Show all existing trees on landscape plans. Indicate trees to be saved or removed.
2. Do not locate curbs closer than 5 feet from the trunk of the tree where possible. Do not provide paving or asphalt closer than 5 feet from the tree trunk.
3. Locate new sidewalks, paving or asphalt to allow breathing space for tree roots. The following should be used as a guideline:
   a. For trees up to 4 inches in trunk caliper, provide 25 square feet of porous area.
   b. For each additional 2 inches of tree caliper, provide 10 additional square feet of porous area.

B. Performance Requirements
1. Cut any severed roots caused from trenching outside the drip line of a tree with smooth and flush cuts. Backfill trenches immediately to prevent roots from drying out.
2. Provide properly constructed barrier fences at trees to be saved to protect the total area within the drip line. The drip line is defined as the area on ground covered by spread of branches.
3. Do not park or store equipment or materials within the drip line of the tree.
4. Prohibit trenching or boring inside the drip line of trees. Trenching or boring will be permitted inside the drip line of a tree only with approval from the University Project Manager.

1.6 Selection of New Plants:

A. Performance Requirements
1. Supply plants from propagating houses, beds, frames or nurseries. Do not provide "Collected" stock unless specified or approved by the University Grounds and the University Project Manager as a substitute.
2. Provide plants with well formed buds of size normal for the species.
   a. Growth increments of shoots for the previous year of a size normal for the season, i.e., not showing stunted growth will be accepted.
   b. Plants that have been in storage for more than one growing season will not be accepted.
3. Provide sound, healthy, and vigorous plants free of harmful insects, diseases and major mechanical injuries. Major mechanical injuries include damages to trunk or branches to the extent it would affect normal growth and/or appearance, or would require pruning or wound treatment.
4. Provide symmetrical plants typical for species and variety.
5. Plant trees in rows that exhibit consistent branching habit, size, form and height.
6. Specify plant sizes.
7. Select plants from specified growing areas as defined below:
   a. Colorado Grown: plants grown in Colorado nursery fields for the major portion of their life.
   b. Colorado Fielded: plants shipped in, which have grown in Colorado for one full growing season or more prior to delivery.
   c. Northern Grown: plants grown in nurseries one year or more located in Hardiness Zones 1 through 5, as shown in USDA Map.
   d. Alternate plants may be proposed by the Contractor if specified types are not available. Gain approval of substitutes by the University Project Manager.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Transportation of Plants:
   1. Protect all plants, bare root, container or balled and burlapped from the time of digging to the time of planting from any conditions that would adversely affect the continued growth of the plant.
   2. Schedule and coordinate delivery and planting with other landscape work.

1.8 WARRANTY

A. Provide a warranty for a period of one (1) growing season after Final Acceptance of landscape work and at no additional cost to the University. Replace any trees, shrubs, ground cover or bulbs that are dead or that are, in the opinion of the University, in unhealthy or unsightly condition, or that have lost their natural shape due to dead branches or excessive pruning of dead branches.

B. The warranty period begins anew for each replaced area or item and extends each time the area or item requires replacement. Replace plantings in accordance with the original specifications.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Planting Seasons:
   1. Plant only after April 15 and before October 1 or as specified on the Drawings without written approval from Architect.
   2. Plan only when weather and soil condition permit in accordance with locally accepted practice. Do not plant during periods of prolonged cold or heat, or during excessively wet or dry periods.

B. Planting:
   1. Stake and verify locations for plants according to the landscape plan.
   2. Prior to any excavation, identify all underground utilities with Utility Services through the University Project Manager.
   3. Plant container grown and balled and burlapped plants as follows:
      a. In clay or clay loam soil, provide a planting pit 2 to 4 inches more shallow than the height of the soil ball, and a minimum of 1 foot larger in diameter.
      b. In sandy loam soil, which is well drained, provide a planting pit depth no deeper than the height of the root ball and a minimum of 1 foot larger.
      c. Remove container plants and tease, manipulate, or scar the fibrous roots with a knife to discourage circling roots. Care should be taken not to break the root ball.
      d. Set balled and burlapped plants in the planting pit at the proper depth, remove all twine from the trunk, and cut excess burlap from the top of the root ball prior to backfilling.
e. Provide tree planting holes twice the size of the root ball and provide proper amended soils mix such as Eco/Bio Planters Mix.

4. Amend backfill soil for bare root plants according to recommendations of the Architect/Engineer. Add backfill and water thoroughly. Settle soil with water to eliminate all air pockets. Do not compact backfill by tamping. If area is irrigated, do not provide a basin. If area is not irrigated, form a basin for water.

5. Provide percolation test to check for adequate air and water movement. If site soil fails the test, notify the University Project Manager. Perform improvement of soil drainage prior to planting. Obtain recommendations through the design team from a soil testing laboratory and/or an agricultural drainage consultant as required.

6. Verify backfill amendments are of a consistency to allow for air and water movement without compacting.

7. Use wire baskets. Remove the bottom of the basket up to the first tier of wire prior to placing the tree in pit. Place the balled tree in the hole at the proper depth, backfill and compact the soil up to the first tier of wire above the bottom of the ball to stabilize it. Remove the remainder of the wire and backfill and compact the soil up to approximately one-third of the bottom portion of the ball. Finish backfilling with loose soil and thoroughly puddle with water.

8. Provide staking, guying and tree wrap. Wrap trees with approved material, e.g. the standard 4 inch crepe wrap. Wrap from the ground line up to the second whorl of branches and secure. Apply wrap approximately November 15 and remove approximately April 15 of the following year. When guy wires are used, they shall be flagged with a conspicuous material and replaced as required by the University Project Manager until guy wires are removed.

9. Prune any injured or broken roots or branches. Trim to a clean, smooth cut without disturbing branch collar. Trim damaged evergreen branches in such a manner that the form of the tree is not affected.

10. Provide safety devices at all open holes or pits to protect the University from liability for personal accidental injury.

C. Plant Maintenance:

1. General: Maintain plants by watering, fertilizing, pruning, restoring planting saucers, tightening and repairing stake supports, resetting trees and shrubs to proper grades or vertical position, spraying as required to keep trees and shrubs free of insects and disease, cultivating and weeding as required for healthy growth or as directed by the Architect.

   a. Monitor watering of plants and lawns to verify overwatering is not causing stress to trees, especially when planted in turf.

   b. Tree wrap:

      1) Apply a coating of insecticide and fungicide to the tree trunk area to be wrapped.

      2) Apply wrap to overlap 1 ½” from ground line up to lowest branch. Wrap trunks in late fall (approximately November 15).

      3) Tie securely in at least five places with jute twine, placed at least 12” apart.

      4) Remove tree wrap at the beginning of the growing season (approximately April 15).

2. Maintenance Period: Begin maintenance immediately after planting. Maintain plants until the end of the Warranty period. If planting occurs in autumn and maintenance has not been performed, or if work was not yet acceptable at the end of the autumn growing season (October 1), continue maintenance the following spring beginning March 15 (or sooner, weather permitting) and continue to the end of the warranty period.
SECTION 33 05 00 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 REFERENCES
A. City of Aurora Standards
B. Denver Water

1.2 SYSTEM PERFORMANCE REQUIREMENTS
A. Design Requirements
1. Any utility piping that will be conveyed to or become owned by the City of Aurora must comply with the City of Aurora Standards. Coordinate with the University Project Manager to determine ownership of utility piping.
2. Nonmetallic Utility Lines:
   a. Provide an insulated 16 gauge tracer wire (or metallic tape) at all new nonmetallic utility lines outside the building envelope to indicate the utility's location to tracing equipment. Locate tape or wire either affixed to the utility, or, if metallic tape, buried with a 12 inch separation directly above the utility. Expose tracer wire at either end of the utility (above grade) and prominently mark with flag after backfill is completed.
   b. Determine the appropriate point and method of termination with the University Project Manager and utility locator/document.
3. Isolation of Utilities:
   a. Provide proper means for isolation before entering the building.
4. Utility Sleeves:
   a. Provide tubing or pipe (not sheet metal) sleeves for all utility services passing through structural walls and slabs. Project all sleeves passing through slab floors a minimum of 2 inches above the slab and seal water tight to the slab.
   b. Fill sleeves with a flexible gas tight caulking.
5. Sanitary and Storm Sewerage:
   a. Provide manholes at major junctions of exterior sewer lines and cleanouts on all other junctions.
   b. Provide manhole covers with holes drilled in lid for use of lifter for removal.
   c. Provide flat and level manhole covers free of projections in driveways and parking lots to avoid interference with snow removal equipment.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 33 05 00
PART 1 - GENERAL

1.1 REFERENCES

A. City of Aurora Standards (for the University of Colorado Anschutz Medical Campus Only)
B. Colorado Department of Public Health and Environment (CDPHE)

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Design Requirements
   1. Identify storm water sumps in a site-specific Storm Water Management Plan (SWMP).

B. Performance Requirements
   1. Provide Best Management Practice (BMP) that provides permanent storm water quality run off control ponds on the University of Colorado Anschutz Medical Campus.
   2. Provide Best Management Practice (BMP) for all construction projects for storm water control regardless of size.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Obtain permit from CDPHE, as required. Coordinate with the University Engineers through the University Project Manager. Refer to 01 41 00 – Regulatory Requirements.

B. The Authority Having Jurisdiction (AHJ) is the University. All projects voluntarily comply with surrounding municipality.

C. Protect storm water inlet grates.

3.2 FIELD QUALITY CONTROL

A. Inspections:
   1. Provide weekly inspections.
   2. Provide inspections after any storm event.
   3. Document all inspections and provide copies to the University Project Manager on a weekly basis.
   4. Provide non-ordinary inspections to show corrective action items (if any) were completed with the University.
   5. Provide one post-construction acceptance inspection with the University.

END OF SECTION 33 40 00