

## Project Manual:

# Indiana State University Dreiser Hall Renovation 221 North 6<sup>th</sup> Street Terre Haute, Indiana 47809

## Volume 2 Division 20 to Division 33

### Owner:



**Indiana State  
University**

Board of Trustees  
210 North 7<sup>th</sup> Street  
Terre Haute, Indiana 47809  
812-237-7779

### Owner's Project Manager



**Indiana State  
University**

Department of Facilities Management  
951 Sycamore Street  
Terre Haute, Indiana 47809  
812-237-8100

### Architect:



**browning day**

626 North Illinois Street  
Indianapolis, Indiana 46204  
Phone 317-635-5030

### MEPT Engineer:



**R.E. Dimond**

and Associates, Inc.  
Consulting Engineers  
732 North Capitol Avenue  
Indianapolis, IN 46204

PHONE: (317) 634-4672 FAX: (317) 638-8725

### Structural Engineer:



4275 North High School  
Indianapolis, Indiana 46254  
Phone 317-293-3542

### Acoustical Engineer:



1650 East 49<sup>th</sup> Street  
Indianapolis, Indiana 46205  
Phone 317-536-8000

## Bid Number B0027086



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## SECTION 200010 – COMMON WORK RESULTS FOR FIRE SUPPRESSION, PLUMBING & HVAC

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this and all Sections of Divisions 20, 21, 22 and 23.

#### 1.02 SUMMARY

- A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Requirements of Regulatory Agencies.
2. Abbreviations contained in Specifications.
3. Shop Drawings.
4. Record Drawings
5. Operation and Maintenance Manuals.
6. Drawings.
7. Construction Documents.
8. Work and Workmanship.
9. Coordination between Contractors.
10. Assignment of Miscellaneous Work.
11. Equipment Warranty and Early Equipment Startup.
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14. Product and Material Approval.
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17. Electrical Connections to Equipment and Control Wiring.
18. Attaching to Building Construction.
19. Rough-ins.
20. Mechanical Installations.
21. Cleaning and Touch-up.
22. General Completion Startup/Owner Orientation.
23. Air Filters.

#### 1.03 REQUIREMENT OF REGULATORY AGENCIES

- A. All materials and workmanship shall comply with all applicable codes, specifications, local ordinances, industry standards and utility company regulations.
- B. In case of difference between building codes, specifications, state laws, local ordinances, industry standards, utility company regulations and Contract Documents, the most stringent shall govern. Contractor shall promptly notify Engineer in writing of any such difference.

- C. Non-compliance: should Contractor perform any work that does not comply with requirements of applicable building codes, state laws, local ordinances, industry standards and utility company regulations, he shall bear all costs arising in correcting the deficiencies.
- D. Applicable codes and standards shall include all state laws, local ordinances, utility company regulations and applicable requirements of the most recent editions of the following nationally accepted codes and standards:
  - 1. The Indiana Building Code. (IBC)
  - 2. The Indiana Electric Code.
  - 3. The Indiana Mechanical Code. (IMC)
  - 4. The Indiana Fuel-Gas Code.
  - 5. The Indiana Fire Code.
  - 6. The Indiana Plumbing Code. (IPC)
  - 7. The Indiana Elevator Code.
  - 8. The Indiana Handicapped Accessibility Code.
  - 9. National Fire Protection Associates (NFPA) codes and regulations.
  - 10. Regulations of the Indiana State Board of Health.
  - 11. Regulations of the Insurance Bureau of Indiana.
  - 12. Requirements of Factory Mutual (FM).
  - 13. Regulations of the Indiana Department of Fire Prevention and Building Services.
  - 14. The Americans with Disabilities Act (ADA).
  - 15. All local and municipal codes and/or regulations.
- E. Except as otherwise specified herein, all piping work and materials are to conform to the American Standards Association Code for Pressure Piping.
- F. All fired and unfired pressure vessels furnished and installed under this contract are to conform to all requirements of current edition of State of Indiana Rules and Regulations for Boilers and Unfired Pressure Vessels. Copies of all certificates of tests and construction as required by this code to be turned over to Owner.
- G. Permits: Contractor shall pay for all building permits required by work and permits for opening streets and for connection to various utilities, including fees for water meter installation and any other requirements necessary to carry out his work. Where streets or sidewalks are cut, same must be repaired to at least as good a condition as they were before, all at expense of this Contractor. Permits shall be posted in prominent place at building site properly protected from weather and physical damage.

#### 1.04 ABBREVIATIONS CONTAINED IN SPECIFICATIONS

- |    |      |   |
|----|------|---|
| A. | AABC | Associated Air Balance Council  |
| B. | ABMA | American Boiler Manufacturers Association                                 |
| C. | ACI  | American Concrete Institute   |
| D. | ACIL | The Association of Independent Scientific, Engineering, and Testing Firms |
| E. | ADA  | Americans with Disabilities Act   |
| F. | ADC  | Air Diffusion Council   |
| G. | AGA  | American Gas Association  |
| H. | AIA  | American Insurance Association  |
| I. | AIHA | American Industrial Hygiene Association                                   |
| J. | AMA  | Air Moving & Conditioning Association                                     |
| K. | AMCA | Air Movement and Control Association International, Inc.                  |
| L. | ANSI | American National Standards Institute                                     |

M.	ARI	Air-Conditioning and Refrigeration Institute
N.	ASA	American Standards Association
O.	ASA	Acoustical Society of America
P.	ASC	Adhesive and Sealant Council
Q.	ASHRAE	American Society of Heating, Refrigerating & Air-Conditioning Engineers
R.	ASME	American Society of Mechanical Engineers
S.	ASPE	American Society of Plumbing Engineers
T.	ASTM	American Society for Testing Materials
U.	AWS	American Welding Society
V.	AWWA	American Water Works Association
W.	AABC	Associated Air Balance Council
X.	CAGI	Compressed Air and Gas Institute
Y.	CE	Corps of Engineers (U.S. Department of the Army)
Z.	CGA	Compressed Gas Association
AA.	CTI	Cooling Tower Institute
BB.	DIPRA	Ductile Iron Pipe Research Association
CC.	DOT	Department of Transportation
DD.	EPA	Environmental Protection Agency
EE.	FCC	Federal Communications Commission
FF.	FDA	Food and Drug Administration
GG.	FIA	Factory Insurance Association
HH.	FCI	Fluid Controls Institute
II.	FM	Factory Mutual System
JJ.	HEI	Heat Exchange Institute
KK.	HI	Hydraulic Institute
LL.	HI	Hydronics Institute (Division of Gas Appliance Manufacturers Association)
MM.	INCE	Institute of Noise Control Engineering
NN.	IEEE	Institute of Electrical & Electronic Engineers
OO.	IRI	Industrial Risk Insurance
PP.	ISA	International Society for Measurement and Control
QQ.	ITS	Intertek Testing Services (Formerly Inchcape Testing Services)
RR.	MCAA	Mechanical Contractors Association of America
SS.	MSS	Manufacturing Standardization Society of the Valve and Fittings Industry
TT.	NACE	National Association of Corrosion Engineers
UU.	NBS	National Bureau of Standards
VV.	NCAC	National Council of Acoustical Consultants
WW.	NEBB	National Environmental Balancing Bureau
XX.	NEC	National Electric Code
YY.	NECA	National Electrical Contractors Association
ZZ.	NEMA	National Electrical Manufacturers Association
AAA.	NETA	InterNational Electrical Testing Association
BBB.	NFPA	National Fire Protection Association
CCC.	NIA	National Insulation Association (Formerly National Insulation and Abatement)
DDD.	NIST	National Institute of Standards and Technology (U.S. Department of Commerce)
EEE.	NUSIG	National Uniform Seismic Installation Guidelines
FFF.	OSHA	Occupational Safety & Health Administration (U.S. Department of Labor)
GGG.	PDI	Plumbing and Drainage Institute
HHH.	PPFA	Plastic Pipe and Fittings Association
III.	PPI	Plastics Pipe Institute
JJJ.	RMA	Rubber Manufacturers Association
KKK.	SMACNA	Sheet Metal & Air Conditioning Contractors' National Association
LLL.	UL	Underwriters Laboratories
MMM.	UNI	Uni-Bell PVC Pipe Association
NNN.	WSC	Water Systems Council

1.05 SHOP DRAWINGS

- A. Review of Shop Drawings does not relieve Contractor of responsibility for correct ordering of material and equipment.
- B. Contractor review should insure that equipment will fit into available space.
- C. Shop Drawings shall be prepared and submitted in accordance with Division 1 "Submittals".
- D. Include all significant data on Shop Drawing Submittals shown in Specifications and Equipment Schedule. Including, but not limited to the following:
  - 1. Name each piece of equipment by scheduled name, noted as: "Mark No." as indicated on drawings, i.e., FC-A, AHU-A, etc.
  - 2. Pressure drops at design flow.
  - 3. Electrical characteristics and wiring diagrams: Power, signal, and control wiring. Wiring diagrams must match the equipment provided. Custom factory wiring such as terminal strip designations must be provided. Costs associated with field changes required if accurate wiring diagrams are not provided shall be borne by the equipment manufacturer.
  - 4. Description of construction and material types and gauge of materials used.
  - 5. Entering and leaving air and or water temperature at design conditions.
  - 6. Performance characteristics/efficiency.
  - 7. Dimensional drawing showing locations of all field connections including piping, control, power and sheet metal as well as equipment configuration.
  - 8. Dimensional drawing showing locations of all field connections including piping, control, power and sheet metal as well as equipment configuration.
  - 9. Note any special tools required for equipment service.
- E. Items Requiring Submittals:
  - 1. Each individual section lists the required items to be submitted.

1.06 COORDINATION DRAWINGS

- A. Contractor shall be responsible for preparation of Coordination Drawings indicating Plans, drawn to scale, on which items are shown and coordinated with each other, using input from installers of the items involved. See Division 23 31 13 for specific requirements.

1.07 RECORD DRAWINGS

- A. Contractor shall be responsible for furnishing to Engineer a complete, accurate and neat set of marked-up blue-line drawings in accordance with Division 1. This set shall contain all deviations between actual construction and Contract Drawings.
- B. Contractor shall maintain a mark-up set of as-built drawings on the project site and shall keep all drawings up-to-date as construction progresses. This marked-up set shall be returned to Contractor, as many times as necessary, in order to obtain desired results.
- C. Engineer's employees shall inspect Drawings regularly on project site for accuracy and omissions. Pay request will not be approved if marked-up record drawings are not onsite and up to date.

- D. Refer to Division 1 "CONTRACT CLOSEOUT" for further instructions.

#### 1.08 CONSTRUCTION DOCUMENTS

- A. Construction documents shall include all divisions of specifications, all drawings and all issued addenda.
- B. In a case of conflict between the drawings and specifications, or between divisions of specifications, the most stringent condition shall apply.

#### 1.09 OPERATION AND MAINTENANCE MANUALS

- A. Prepare Operation and Maintenance Manuals including the following information for equipment items:
  - 1. Complete index identifying contents of manual. Also provide a comprehensive list of manufacturers, suppliers, subcontractors, etc., with name of contact person, address and phone number for each manufacturer, supplier and subcontractor.
  - 2. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and exploded drawing of devices with names and part numbers of replacement parts.
  - 3. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
  - 4. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
  - 5. Servicing instructions and lubrication charts and schedules.
  - 6. Warranty letter from contractor stating general warranty and any extended warranty items included in this contract.
  - 7. Refer to Division 1 "Contract Closeout" for additional instructions.

#### 1.010 DRAWINGS

- A. Mechanical Drawings show general arrangement of all piping, equipment and appurtenances. They shall be followed as closely as actual building construction and work of other trades will permit. Mechanical work shall conform to requirements shown on all Drawings. General and Structural Drawings shall take precedence over Mechanical Drawings. Because of small scale of Mechanical Drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required. Contractor shall investigate structural and finish conditions affecting work and shall arrange his work accordingly, providing such fittings, valves and accessories as may be required to meet such conditions.
- B. For purpose of clarity and legibility, Drawings are essentially diagrammatic, although size and location of equipment and piping are drawn to scale wherever possible. Verify Contract Document information at site.
- C. Drawings indicate required sizes and points of termination of pipes and ducts and suggested routes. It is not the intention of Drawings to indicate all necessary offsets. Install work in manner to conform to structure, avoid obstructions, preserve headroom and keep openings and passageways clear. Do not scale from Drawings.

- D. In case of a conflict in construction documents and or the specifications, Contractor shall receive clarification, prior to bidding, in the form of an addendum or include in his price, the greater amount of work of the conflicts shown. (i.e., if two pipe sizes are indicated for the same pipe, the Contractor shall price the larger of the two pipes.)

#### 1.011 WORK AND WORKMANSHIP

- A. Provide all required labor, materials, equipment and Contractor's services necessary for complete installation of systems required in full conformity with requirements of authorities having jurisdiction; and as indicated on Drawings and herein specified.
- B. Finished job shall be functional and complete in every detail, including any and all such items required for a complete system, whether or not these items are specified or shown on drawings.
- C. Any apparatus, material or work not shown on Contract Drawings but mentioned in the Specifications, or vice versa, or any incidental accessories or minor details not shown but necessary to make the work complete in all respects and ready for operation, even if not particularly specified, shall be provided without additional expense to the Owner.
- D. Special attention shall be given to accessibility of working parts and controlling parts. Adjustable parts shall be within easy reach. Removable parts shall have space for removal.
- E. Each Contractor shall acquaint himself with details of all work to be performed by other trades and take necessary steps to integrate and coordinate his work with other trades.
- F. It is assumed the Mechanical Contractor is familiar with standard first class installation procedures. Therefore, these Specifications do not attempt to include every detail or operation necessary for the complete installation.
- G. It should be particularly noted that the terms "furnish" and "provide" are interchangeable and that each of these terms means to provide, install and connect, unless otherwise stated.
- H. Whenever tables or schedules show quantities of materials, they shall not be used as a guide to Contractor. Each Contractor shall be responsible for furnishing all materials noted on Drawings and as specified.
- I. Craftsman trained in each respective trade shall install work in that trade.

#### 1.012 COORDINATION BETWEEN CONTRACTORS

- A. Each Contractor and Subcontractor shall study all Drawings applicable to this work so complete coordination between trades will be affected. Special attention shall be given to points where ducts cross other ducts or piping, where lights fit into ceilings and where pipe, ducts and conduit pass through walls and columns. Temperature controls interface, where applicable, shall be given attention.
- B. It is responsibility of each Contractor and Subcontractor to leave necessary room for other trades. No extra compensation will be allowed to cover cost of removing piping, conduit, ducts or equipment found encroaching on space required by others.

1.013 ASSIGNMENT OF MISCELLANEOUS WORK

- A. Lintels required by Contractor in new or existing walls shall be furnished by Respective Contractor. Contractor shall be responsible for notifying other Contractor of correct size and locations for all lintels prior to wall construction.
- B. Painting: Respective Contractor will provide prime painting on all ferrous metals such as supporting steel or hangers for mechanical piping and equipment. Piping itself is not to be primed. Any finish painting required, including painting of all mechanical items exposed to outside environment will be painted by Respective Contractor.
- C. Roof Openings: required by Mechanical Contractor shall be cut by RESPECTIVE Contractor. Mechanical Contractor is responsible for correct size and location of same.
- D. Roof Curbs and Bases: for roof mounted mechanical equipment shall be furnished and anchored to structure by RESPECTIVE Contractor.
- E. Flashing: for roof curbs and bases shall be furnished by RESPECTIVE Contractor.
- F. Counter flashing for roof curbs and bases shall be furnished by OTHER Contractor.
- G. Louvers: furnished by OTHER Contractor. Size and location verified by RESPECTIVE Contractor.
- H. Pads and Foundations: for mechanical equipment shall be formed and poured by RESPECTIVE Contractor. The RESPECTIVE Contractor shall verify pad sizes, locations and all anchoring devices.
- I. Platforms and Supporting Stands: for mechanical equipment shall be furnished by RESPECTIVE Contractor unless noted otherwise.
- J. Penetrations: holes required for piping or ductwork shall be cut in field at expense of RESPECTIVE Contractor. Engineer shall give approval prior to any cutting.
- K. Penetrations through Structure: holes required for piping or ductwork shall be cut or installed as walls are erected at the expense of the RESPECTIVE Contractor unless indicated by others as detailed on structural drawings. Mechanical Contractor to coordinate location and size of all openings prior to building erection or he will assume all costs for providing openings. Engineer shall give approval prior to cutting.
- L. Excavating and Backfilling: for mechanical work shall be by RESPECTIVE Contractor.
- M. Outside Downspouts: shall be by OTHER Contractor. Downspouts shoe shall be by OTHER Contractor.
- N. Chemical Treatment, system fill, and glycol(where applicable) of closed loop systems by Respective Contractor.
- O. Caulking of all plumbing fixtures shall be by Mechanical Contractor.
- P. All fire stopping of mechanical penetrations by RESPECTIVE Contractor.

- Q. All caulking of mechanical penetrations through interior partitions by RESPECTIVE Contractor. All sleeve seals for mechanical penetrations through exterior below grade penetrations by Mechanical Contractor.
  - R. Mechanical Contractor will install all taps, control valves and thermo wells in piping for all temperature sensors, flow switches, pressure sensors and any other control device installed in piping whether shown or not on the Drawings.
  - S. Dust Protection:
    - 1. Temporary partitions or barriers required to protect existing building or facilities specifically in areas requiring primarily mechanical work; i.e., cross country pipe, etc., shall be provided by RESPECTIVE Contractor. RESPECTIVE Contractor shall coordinate necessity and location of such protection with Owner.
    - 2. Temporary filters for protection of new and existing ductwork and equipment as required during construction is to be by the RESPECTIVE Contractor.
  - T. Pipe identification shall be by Mechanical Contractor as specified in Section 20 00 50.
  - U. Temporary Use of Equipment: should it become necessary or desirable to operate any equipment before final acceptance, Owner shall be allowed to do so, ONLY after proper adjustments and trial operation by Contractor specified. RESPECTIVE Contractor shall be responsible for instructing Owner, or his Representative, as to proper operation and care of equipment so used. If equipment is used prior to final acceptance of job, date of first usage will begin warrantee period.
  - V. All electrical control wiring between mechanical equipment (i.e., air cooled chiller and condensing unit, etc.) shall be by CONTROL Contractor.
  - W. Cutting and Patching: RESPECTIVE Contractor shall cut and patch finished areas as required by Mechanical Contractor.
  - X. Wall Sleeves in new construction for Mechanical systems shall be provided by the RESPECTIVE Contractor and coordinated by Mechanical Contractor.
  - Y. Wall Sleeves in existing construction shall be provided and installed by the RESPECTIVE Contractor.
  - Z. Ceiling and Wall Access Panels: shall be located by mechanical contractor and installed by OTHER Contractor.
- 1.014 EQUIPMENT WARRANTY AND EARLY EQUIPMENT STARTUP
- A. Contractor shall provide a complete warranty for all equipment, controls, etc. that includes parts and labor, any equipment that fails shall be repaired and/or replaced at no cost to owner.
  - B. The warranty shall start on the date of substantial completion. On projects with multiple phases, the date of substantial completion of the final phase shall be the date that the warranty starts for all phases, i.e. the entire project. No exceptions.
  - C. If special extended warranties exist they will be noted in the respective sections. Extended warranty start on the date of Substantial Completion of the final phase, unless another date is agreed to by all parties.

- D. If equipment startup is required to provide suitable climate conditions for carpentry finish trim, painting, ceiling tile installation, etc., then this contractor is responsible for starting, operating equipment and providing an extended warranty.
- E. Respective Contractor shall provide temporary filters over ductwork on all equipment if equipment is started early.
- F. The “umbrella” warranty for the project shall be one year.
- G. Some devices such as Control Valves, etc. require extended warranties. Extended warranties are noted in the Specification Section for that piece of equipment. The prime Contractor shall be responsible for all implementation and cost of extended warranty work.

#### 1.015 MATERIAL AND EQUIPMENT TRANSPORT

- A. All material and equipment, shipped to site, shall be suitably covered and protected during shipment to site.
- B. Protection shall include shrink wrapping and desiccant bags for humidity controls.
- C. Protect equipment from weather, road salts, road dirt, condensation, damage and all other situations that can be detrimental to the condition of the equipment and material being shipped.
- D. Engineer will not be on site during delivery; however, Engineer reserves the right to reject material or equipment after the fact that is delivered to site in unsatisfactory condition.

#### 1.016 MATERIAL STORAGE

- A. Provide suitable protection from weather and vandalism for all materials and equipment to be installed. Storage shall be dry, clean and safe. Provide heat as required to stop condensation. Condensation occurs during periods of large ambient temperature swings, i.e. spring or fall. Any materials or equipment damaged, deteriorated, rusted or defaced due to improper storage shall be fully repaired, refinished or replaced, as directed by Engineer at no additional cost.

### PART 2 - PRODUCTS

#### 2.01 PRODUCT AND MATERIAL APPROVAL

- A. A Specification followed by one or more manufacturers is limited to those manufacturers. Names of other manufacturers may be submitted for approval, to the Engineer, a minimum of ten calendar days prior to receiving bids. Approval will be issued by Addendum if approval is granted.
- B. The mechanical equipment shall be new, listed by UL and shall confirm to NEMA requirements.
- C. If changes in pipe, ductwork, conduit, wiring, structural support, ceiling space, etc. are required as a result of the contractor's decision to purchase equipment with a different arrangement than shown on the Drawings, the Contractor shall be responsible for including all associated costs in their bid. Manufacturers listed on schedules shall be considered “basis of design” (BOD). Note that manufacturers listed as equals may have physical characteristics such as weight, footprint,

sound levels, electrical, etc, which require more coordination, piping, wiring, and/or general construction changes. The Mechanical Contractor will be responsible for all additional costs associated with the installation of this equipment. Contractors should seek clarification prior to bid for any equipment that does not meet or exceed the scheduled or specified characteristics.

### PART 3 - EXECUTION

#### 3.01 PROTECTION AND TREATMENT OF PROPERTY

- A. Repair and replace all property damaged in installation of underground lines to meet approval of Owner and authorities having jurisdiction.
- B. Protect existing utilities. Cap existing utilities that are abandoned.
- C. All property in existing facilities that is damaged/removed, by contractor operations shall be repaired/replaced to previous operating and appearance condition.

#### 3.02 DEMOLITION AND REMOVAL OF EQUIPMENT

- A. Contractor shall remove all equipment, hangers and support for portion of mechanical system in present building as indicated on Drawings and/or implied by nature of the work to be removed. Contractor shall remove all pipes and ductwork back to source made obsolete by removing equipment unless specifically instructed otherwise.
- B. Contractor shall properly support remaining portions of the work. Contractor shall provide valves, plugs, vents, etc. as required so existing systems remain operational.
- C. Owner shall have first right of refusal on all equipment, piping, etc., being removed. If owner decides to keep removed items, then the contractor shall move items to a location on this project site as directed by owner.
- D. Openings remaining after equipment has been removed shall be patched to match surrounding surfaces and in conformance with good practice.

#### 3.03 ELECTRICAL CONNECTIONS TO EQUIPMENT AND CONTROL WIRING

- A. All electrical work shall be done in accordance with the latest edition of the National Electric Code.
- B. All above ground wiring shall be installed in metallic conduit with a minimum conduit size of ¾ inch. All wiring shall be concealed, except in equipment rooms, crawl spaces, tunnels and mechanical or electrical closets. Conduit shall be fastened securely at regular intervals and shall be run parallel to the building lines.
- C. Running low voltage wire above bar joist in roof/floor metal deck flutes is not permitted. Wire to be run above bottom chord of truss and fastened to structure with wire ties at maximum 4' o.c.
- D. All flexible conduit shall not exceed 2 foot.

- E. All below ground wiring shall be installed in rigid conduit with minimum size of  $\frac{3}{4}$ ". Conduit system shall be sealed watertight.
- F. Provide all wire, conduit, fittings, miscellaneous materials and labor as required for mounting and connecting the electrical control devices furnished in this contract.
- G. All wiring shall be continuous from point to point. No splicing between terminations allowed.
- H. In the event that a Supplier of equipment requires a larger starter, disconnect wiring conduit, etc. than those indicated in Contract Documents, he shall reimburse Contractor supplying these items for the difference.
- I. Connections and wiring diagrams shown on Drawings or described in Specifications are typical and for bidding purposes only. Detailed diagrams and instructions shall be provided by Contractor supplying the equipment. If connections are different from those shown on Drawings, Mechanical Contractor shall reimburse Electrical Contractor for those differences.
- J. Additional relays switches, contactors, etc. which may be required for control purposes in addition to those specified and indicated on Drawings shall be provided by Mechanical Contractor.
- K. In the event that several pieces of mechanical equipment from different Suppliers are combined in one system, Mechanical Contractor shall furnish complete wiring and control diagrams to enable Electrical Contractor to make proper connections. Diagrams shall be submitted to Engineer for review, prior to actual wiring.
- L. Mechanical Contractor shall furnish to Electrical Contractor written notice of approval and acceptance for all control wiring installed for mechanical systems by Electrical Contractor. Such approval shall be given within 30 days of completion of all such control wiring. Two copies of letter shall be sent to Engineer.

### 3.04 ATTACHING TO BUILDING CONSTRUCTION

- A. Equipment and pipe supports shall be attached to structural members (beams, joists, etc.) rather than to floor or roof slabs. Support from structural members shall be in accordance with manufacturer recommendation of structural member and/or approved by Structural Engineer.
- B. Where piping is suspended from new concrete construction, furnish, locate and install black steel channel type concrete inserts before concrete is placed. Fasten inserts to forms and install reinforcing bars through openings at top of inserts. Inserts shall provide for horizontal and vertical adjustments.
- C. Where piping is suspended from existing concrete or masonry construction, use expansion shields to attach pipe supports to construction.
  - 1. Anchors shall be installed horizontally into the sides (vertical portion) of concrete beams at a minimum of 5" from the bottom of the beam.
  - 2. When support location is between concrete beams, then unistrut shall be attached to sides of concrete beams and span continuously between the concrete beams. Unistrut shall be sized per manufacturer's data to carry load.
  - 3. Contractor must receive prior approval before attaching to the underside of concrete slabs or concrete beams.

4. Install all anchors according to manufacturer's written instructions. Expansion shield bolt diameter shall be same size as support rod diameter hereinafter specified. If, in the opinion of the Owner/Engineer, existing structure is questionable, an angle will be required with two expansion shields to carry each vertical support rod. Expansion shields shall be combined friction and keying hold type wedge anchor like HILTI Red Head or approved equal.
- D. Where existing masonry is not suitable to receive and hold expansion shields or where other means of attachment is advantageous, Contractor shall submit alternate method for approval of ENGR..
- E. Where piping is suspended from structural steel building framing or supporting members, furnish and install beam clamps for attaching piping support device to building member.
- F. Obtain approval from ENGR. before cutting or welding to structural member or before hanging heavy equipment.
- G. Support piping and ductwork from structure so that equipment connections are not being used for support.

### 3.05 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be installed.
- B. Refer to shop drawings for equipment rough-in requirements.

### 3.06 MECHANICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
  1. Keep all major equipment covered, in buildings, until major dust producing activities are complete. Equipment to be covered includes chillers, pumps, VFD's and AHU's.
  2. All equipment must be installed such that maintenance and service may be properly accomplished. If necessary, the Owner, at their option, may require the contractor to demonstrate the service on any piece of equipment to determine sufficient service space exists. If the service space is not adequate, the equipment shall be relocated at no additional cost to the Owner such that sufficient service space is achieved.
  3. Coordinate mechanical systems, equipment, and materials installation with other building components.
  4. Verify all dimensions by field measurements.
  5. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
  6. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
  7. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
  8. Where mounting heights are not detailed or dimensioned, install systems, material, and equipment to provide the maximum headroom possible.

9. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
10. Install systems, materials, and equipment to conform with engineer reviewed submittal data. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.
11. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
12. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
13. Extend grease fittings to an accessible location.
14. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at specified slope.
15. All shutdowns required to connect to existing systems shall be scheduled and coordinated with the Owner. Contractor shall prefabricate and install new materials as much as possible to keep shutdown duration to a minimum.
16. All pipe, duct and mechanical equipment shall be installed as high above floor (close to structure) as possible. When any pipe, duct or mechanical piece of equipment is installed lower than 7'-0" above finished floor, foam type insulation with black and yellow caution marker tape shall be installed on bottom leading edges.
17. Contractor shall field verify all locations, sizes and connection points to existing piping, ductwork and systems as shown on the drawings. Contact Engineer with any discrepancies.
18. Provide all contact information to Test and Balance Contractor 30 days prior to start up of equipment.
19. Contact Test and Balance Contractor after leakage and pressure test on air and water systems has been successfully completed.

B. Platforms and Supporting Stands

1. Each piece of equipment or apparatus suspended from ceiling or mounted above floor level shall be provided with suitable structural support, platform or carrier, in accordance with best recognized practice.
2. Contractors shall exercise extreme care that structural members of building are not overloaded by such equipment. In all cases, details of such hangers, platforms and supports, together with total weights of mounted equipment, shall be approved by ENGR.

C. Drive Guards

1. All belt-driven equipment shall have belt guards with provisional slot for tachometer reading access at shaft. All rotating equipment and drives shall have safety guards.

3.07 CLEANING AND TOUCH UP

- A. All mechanical equipment, cabinets, control panels and other enclosures shall be cleaned and have paint touched up as necessary to duplicate factory finished appearance. Touch up paint shall exactly match color, composition and quality of factory applied finish.

- B. Equipment furnished with factory applied finish shall be protected from damage by the installing Contractor. Any damaged surface shall be repaired or replaced by the installing Contractor to match original finish or shall be replaced before final acceptance.

### 3.08 GENERAL COMPLETION, STARTUP

- A. Work Included: furnish materials and labor required to perform startup of equipment and systems installed on project and provide operating instructions to Owner.
- B. It is Mechanical Contractors' responsibility to conduct an owner orientation meeting which will review all systems, their operation and operation of all equipment.
- C. General Requirements.
  - 1. Inspect bearings for cleanliness and alignment and remove any foreign materials found. Grease as necessary and in accordance with manufacturer's recommendations. Replace bearings that run rough or noisy.
  - 2. Adjust tension in V-belt drives, adjust vari-pitch sheaves and drives for proper equipment speed. Change belts and sheaves if necessary to obtain proper equipment speed; remove any foreign materials from sheaves or belts before starting operations; adjust drives for alignment of sheaves and v-belts. Construe proper speed as that which produces intended performance. Change sheaves so that design CFM is achieved when VFD is at 100%. Slowing VFD to meet maximum design CFM is not acceptable.
  - 3. Tighten flanges and packing glands after system has been placed in operation. Replace gaskets in flanges that show any signs of leakage after tightening.
  - 4. Inspect screwed joints for leakage and remake each joint that appears to be faulty. Do not wait for rust to form. Clean threads on both parts, apply compound and remake joint.
  - 5. Adjust pipe hangers and supports for correct pitch and alignment.
  - 6. Flush systems and clean all strainers. After 30 days of operation clean strainers again.
  - 7. Provide such continuing adjustment services as is necessary to insure proper functioning of all mechanical systems after building occupancy and during guarantee period.
  - 8. Provide duct stiffeners, air straighteners, or turning vanes as required to stop any oil canning, drumming or fan surge to the satisfaction of the engineer.

### 3.09 Air Filters

- A. Provide a total of three (3) sets of air filters for each piece of equipment.
- B. Never operate equipment without air filters. Provide construction set of air filters for equipment operation prior to substantial completion.
- C. Replace construction air filters in each and every piece of equipment within 2 weeks after substantial completion. Provide one additional set of air filters to Owner.

END OF SECTION 200010

## SECTION 200050 – COMMON MATERIALS & METHODS FOR FIRE SUPPRESSION, PLUMBING & HVAC

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this and all Sections of Divisions 20, 21, 22 and 23.

#### 1.02 SUMMARY

- A. Provide equipment, materials, labor and services common to more than one section of Divisions 20, 21, 22 and 23. The work generally includes, but is not limited to the following:
  - 1. Vibration Isolators
  - 2. Electric Motors
  - 3. Pressure Gauges
  - 4. Thermometers
  - 5. Separable Sockets
  - 6. Pressure and Temperature Test Plugs (Pete's Plugs)
  - 7. Sleeves
  - 8. Firestop Sealants and Caulks
  - 9. Mechanical Sleeve Seals
  - 10. Elastomeric Joint Sealants
  - 11. Pipe Identification
  - 12. Mechanical Service Color
  - 13. Equipment Identification
  - 14. Paint
  - 15. Grout
  - 16. Concrete
  - 17. Ceiling and Wall Access Panels
  - 18. Thermostats and Sensors

#### 1.03 SUBMITTALS

- A. If specified products are provided, submittals are not required for products provided in this section.
- B. If it is desired to use products that are not specified, then those products must be submitted for review prior to ordering said products.

## PART 2 - PRODUCTS

### 2.01 VIBRATION ISOLATORS

- A. General: Mount equipment on isolators as noted in Schedule of Usage and as noted in specific specification sections. Isolators shall be furnished by manufacturer of isolators. They shall be engineered for specific piece of equipment.
  - 1. Manufacturers:
    - a. Mason Industries, Inc.
    - b. Kinetics Noise Control, Inc.
- B. Types of Isolators
  - 1. Neoprene Pad: Cross ribbed pad 3/8" thick.
  - 2. Cork Rib Pad: 1" thick laminated pad consisting of cork bonded between 2 layers of ribbed neoprene. Vibration Mountings Cork Rib Pak.
  - 3. Steel Spring Mounting: Steel housing containing steel springs with top plate, leveling bolt, snubber fastening slots and neoprene pad bonded to bottom.
  - 4. Rubber in Shear Hanger: Neoprene single or double deflection as required.
  - 5. Spring Type Hangers: Deflection to 2".
  - 6. Combination Spring and Rubber in Shear Hangers: Deflection to 2 1/2".
- C. Submittals shall show frequency, required efficiency and designed deflection.
- D. All vibration isolators shall be selected at 95% efficiency.
- E. Schedule of Usage.
  - 1. Blower Unit Heater: Rubber in shear hangers.
  - 2. Central Station Air Conditioners: Internally Spring Isolated.

### 2.02 ELECTRIC MOTORS

- A. Service:
  - 1. Constant Speed Motors: PREMIUM-EFFICIENCY, NEMA Design B, Class B insulation, nameplated and designed for electrical characteristics noted on Drawings in accordance with NEMA and IEEE Standards.
  - 2. Variable Speed Motors: PREMIUM-EFFICIENCY, NEMA Design B, drive rated with Class F insulation, nameplated and designed for electrical characteristics noted on Drawings and in accordance with NEMA and IEEE Standards. All end plates shall be cast iron. Aluminum end plates are not acceptable.
    - a. Variable speed motors shall include installation of a maintenance free, circumferential, conductive micro fiber shaft grounding brush to divert shaft currents to ground. Aegis model SGR or approved equal.
    - b. Variable speed motors shall be in compliance with NEMA MG1-2006, Part 31, Section 4.4.2 as pertains to voltage spikes. (This is to help prevent premature

motor winding failures when there is a long cable distance between VFD and motor).

- B. General: Motor shall be at least HP specified.
- C. Bearings: Ball, sleeve or roller bearings with dustproof rings.
- D. Temperature Rise: Continuous rating at 104°F (40°C) above ambient.
- E. Base: Cast iron or steel with adjustable slide rail.
- F. Rating: Motors specified for voltage of 220 to 240 volts and 440 to 480 volts shall have 230/460 rating. Motors specified for voltage of 208 volts shall be designed and nameplated for 200 volts.
- G. Enclosures:
  - 1. Hazardous Locations:
    - a. Explosive Liquid Vapor and Gasses: Class I Explosion Proof.
    - b. Combustible Dust (i.e., Coal, grain flower:): Class II - Dust Ignition Resistant.
  - 2. Outside: Totally Enclosed Fan Cooled (TEFC).
  - 3. All others: Open Drip-Proof (ODP) unless noted otherwise with a specific piece of equipment.

#### NEMA Premium™

#### Product Scope and Nominal Efficiency Levels

The NEMA Premium™ efficiency electric motor program scope is single-speed, polyphase, 1-500 horsepower, 2, 4 and 6 pole, squirrel cage induction motors, NEMA Design A or B, continuous rated.

- H. Sizing:
  - 1. Select motors to have required capacity to operate driven equipment under all conditions of operation without overload.
  - 2. Do not include motor service factor when determining motor size.
- I. Manufacturers:
  - 1. Allis Chalmers
  - 2. General Electric
  - 3. Louis Allis
  - 4. Reliance
  - 5. Westinghouse
  - 6. Century
  - 7. Marathon
  - 8. Baldor

## 2.03 PRESSURE GAUGES

- A. Accuracy ASME/ANSI B40.1 Grade 1A (1%).
- B. 4-1/2" minimum diameter dial, stainless steel bourdon tube, lower connection.
  - 1. Manufacturers:
    - a. Ashcroft 1379S
    - b. Hellicoid 440
    - c. U.S. Gauge 1600
    - d. Duro United Series #10
    - e. Weksler 300 Series
    - f. Terice No. 4500 Series
- C. Pressure Snubbers: Piston type like WEKSLER RS1.

## 2.04 THERMOMETERS

- A. Provide and install light powered digital thermometers to meet the following criteria.
  - 1. Display: 3/8" LCD digits
  - 2. Accuracy: 1%
  - 3. Range: -40/300°F
  - 4. Humidity: Operational in ambient conditions up to 100% RH.
  - 5. Case: High impact
  - 6. Stem length to fit separable sockets. Reference separable sockets for required length.
  - 7. Adjustable joint mounting so head can swivel and rotate for best visibility.
  - 8. Heads shall be replaceable without any loss of water from system.
- B. Manufacturers:
  - 1. Weiss Vari-angle digital thermometer
  - 2. Trend Instruments Inc.
  - 3. Winters 9IT
  - 4. Terice

## 2.05 SEPARABLE SOCKETS

- A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.
  - 1. Material: Brass, for use in copper piping.
  - 2. Material: Stainless steel, for use in steel piping.
  - 3. Material: Steel, for use in steel piping
  - 4. Extension-Neck Length: Nominal thickness of 2 inches (50 mm), but not less than thickness of insulation. Omit extension neck for sockets in piping not insulated.
  - 5. Insertion Length: To extend to a minimum of 1/3 (one-third) of diameter of pipe.

## 2.06 PRESSURE AND TEMPERATURE TEST PLUGS (PETE'S PLUGS)

- A. Plug shall be brass or stainless steel arranged for a 1/8" diameter shaft to enter into the plug. The plug shall be rated for 350°F for water and 200°F for gases. The plug shall be equipped with a pipe cap. The plug system shall be rated for zero leakage to 250 PSIG.
- B. Manufacturer:
  - 1. Sisco
  - 2. Trerice
  - 3. Peterson Equipment

## 2.07 SLEEVES

- A. Steel Sheet Metal: 0.0239-inch (0.6-mm) minimum thickness, galvanized, round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
- E. Sleeves shall be in accordance with following schedule unless otherwise specified.

PIPE SIZE	UNINSUL.	1" INSUL.	1-1/2" INSUL.	2" INSUL.
1"	2	4	6	6
1-1/2"	3	4	6	8
2"	3	6	8	8
3"	4	6	8	10
4"	6	8	10	10
6"	8	10	12	12
8"	10	12	12	14

## 2.08 FIRESTOP SEALANTS AND CAULKS

- A. Penetration Sealant:
  - 1. 3M Brand "Moldable Putty Pads and "Moldable Putty Stix".
  - 2. 3M Brand "Fire Barrier" Caulk, Putty or Penetrating Sealing Systems.
  - 3. Dow Corning "Fire Stop Foam" and "Fire Stop Sealant" systems.
  - 4. Insta-Foam Products, Inc. "Insta-Fire Seal Silicone RTV Foam".
  - 5. Standard Oil Engineering Materials Company "Fyre Putty".
- B. Intumescent Sealant:
  - 1. 3M Brand "Fire Barrier" caulk or putty, FS-195 Wrap Strip and CS-195 Composite Sheet.
  - 2. Dow Corning "Fire Stop Intumescent Wrap Strip".

3. Fox Couplings, Inc. "The Fox Cast-in-Place Coupling".
  4. For plastic pipe penetrations up to 4" diameter: Use 3M pre-manufactured fire barrier plastic pipe devices or equal.
  5. For plastic pipe penetrations larger than 4" diameter: Use 3M fire barrier RC-1 restricting collar with FS-195+ wrap/strip or equal.
- C. Performance Characteristics: Firestopping materials shall conform to both Flame (F) and Temperature (T) rating as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire tests.
1. F Rating shall be a minimum of one hour but not less than the fire resistance rating of the assembly being penetrated.
  2. Conduct the fire test with a minimum positive pressure differential of 0.01" of water column.
- D. Quality Assurance: Installer qualifications – firm specializing in firestopping installation with not less than two years of experience or trained and approved by firestopping manufacturer.

## 2.09 MECHANICAL SLEEVE SEALS

- A. Description: Modular design with interlocking rubber links shaped to continuously fill annular space between pipe and sleeve. Include connecting bolts and pressure plates.
- B. Manufacturers: Thunderline/Link-Seal; Calpico, Inc.; MetraFlex Co.

## 2.010 ELASTOMERIC JOINT SEALANTS

- A. Sealant: Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated. Per ASTM C 920 like Dow Corning 995 GE Silicones, Tremco Spectrum 1 or equal.
- B. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26°F (minus 32°C). Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and otherwise contribute to optimum sealant performance. Verify compatibility with Elastomeric Joint Sealant Manufacturer prior to use.
- C. Primer: Material recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- D. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants with joint substrates.

## 2.011 PIPE IDENTIFICATION

- A. Labeling shall consist of the following:

1. Pipe identification to comply with ASME A13.1.
2. Identification of medium in pipe using all uppercase letters.
3. Arrow indicating direction of flow.

B. Banding shall consist of the following:

1. Color-coded band to conform to color code hereinafter specified.

- a. For pipe diameter of 6" or less (including insulation):

<u>PIPE DIA.</u>	<u>SIZE OF LETTERS</u>	<u>LENGTH OF COLOR FIELD</u> <b>(Use only if banding)</b>
3/4" – 1 3/8"	1/2"	8"
1 1/2" – 2 3/8"	3/4"	8"
2 1/2" – 6"	1 1/4"	12"

- 1) Manufacturer: Seton Setmark "SNA" Marker. Graphic Products, or approved equal.

- b. For pipe diameter of 6" or greater (including insulation):

<u>PIPE DIA.</u>	<u>SIZE OF LETTERS</u>	<u>LENGTH OF COLOR FIELD</u> <b>(Use only if banding)</b>
6" – 7 7/8"	1 1/4"	12"
8" – 10"	2 1/2"	24"
Over 10"	3 1/2"	32"

- 1) Manufacturer: Seton Setmark "STR" Marker, Graphic Products or approved equal.

2.012 PLASTIC LAMINATE SIGNS FOR EQUIPMENT IDENTIFICATION

- A. ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore.

1. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
2. Punch for mechanical fastening.
3. Thickness: 1/8 inch (3.2mm) , unless otherwise indicated.
4. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.
5. Nomenclature: Name and plan number as shown on Equipment Schedules and on Drawings or as directed by the Owner.
6. Size: Approximate 2 1/2 by 4 inches (65 by 100mm) for control devices, dampers, and valves; and 4 1/2 by 6 inches (115 by 150 mm) for equipment.

2.013 PAINT

- A. Sherwin-Williams "TILECLAD II" 2-part epoxy, color: gray or white.

## 2.014 GROUT

- A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
  - 1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
  - 2. Design Mix: 5000-psig (34.5-MPa), 28-day compressive strength.
  - 3. Packaging: Premixed and factory packaged.

## 2.015 CONCRETE

- A. Concrete shall be 1 part Portland cement, 2 parts sand and 4 parts gravel or broken stone that will pass through a 1" diameter hole. Clean sharp sand, washed gravel and Portland cement, Atlas, Alpha, LoneStar, Universal or approved equal, shall be thoroughly mixed in a dry condition until color of mixture is uniform. This mixture shall be uniformly spread and gravel evenly distributed thereon, then wet and thoroughly mixed to a consistency that will need no tamping but can be easily faced for spading. Hand mixed concrete shall be prepared upon substantially constructed, tight bottom platforms and shall be mixed in batches not to exceed 1 cubic yard per batch. If concrete is machine-mixed, it shall not be mixed until same can be immediately placed. No concrete which has taken initial set shall be used.

## 2.016 CEILING AND WALL ACCESS PANELS

- A. Plastered Wall or Ceiling: 24" x 24" unless otherwise noted. Constructed to receive plaster to match adjacent finish. Milcor Style B.

## 2.017 THERMOSTATS AND SENSORS

- A. Refer to individual equipment specifications and temperature controls specifications for device specifications.

## PART 3 - EXECUTION

### 3.01 PRESSURE GAUGES

- A. Connection in Piping: provide spare pressure snubbers and install ahead of each gauge to minimize gauge needle pulsations as directed by Engineer. Install 1/2" ball valve to isolate each gauge. Mount gauges for maximum visibility from floor.
- B. Where gauges are installed across pumps to measure differential pressure, install two (2) 1/2" ball valves, one in pipe from pump suction and one in pipe from pump discharge.
- C. Install siphons on all steam gauges: brass or steel.
- D. Scale Ranges
  - 1. Hot Water Heating: 0-160 psig

2. Domestic Water: 0-150 psig
3. Chilled Water: 0-160 psig
4. Steam High Pressure: 0-160 psig
5. Steam Low Pressure: 0-60 psig
6. Steam Condensate: 0-60 psig

### 3.02 THERMOMETERS

#### A. Connection in piping

1. Mount sockets in vertical up position to facilitate their being filled.
2. Mount and adjust thermometers so they may be read standing on floor without using ladder or straining back.

#### B. Scale Ranges

1. Chilled and Condenser Water: 0-120°F
2. Hot Water Heating: 30-240°F
3. Domestic Cold Water: 0-130°F
4. Domestic Hot Water: 30-240°F

### 3.03 PRESSURE AND TEMPERATURE TEST PLUGS (PETE'S PLUGS)

- A. Install Pete's Plugs at each and every piece of hydronic equipment including coils, heat exchangers and pumps and install where shown on Drawings.
- B. Install Pete's Plugs in 1/4" plugged bosses at pump suction and pump discharge flanges.
- C. Always install Pete's Plugs on equipment side of balance valves to measure true differential pressure across equipment, and not across balance valve.

### 3.04 ESCUTCHEONS

- A. Escutcheons: Manufactured wall, ceiling and floor plates; deep-pattern of type required to conceal protruding fittings and sleeves.
  1. ID: Closely fit around pipe, tube, and insulation of insulated piping.
  2. OD: Completely cover opening and sleeve.
- B. Install pipe escutcheons for exposed pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
  1. Chrome-Plated Piping: Cast brass, one piece, with set screw, and polished chrome-plated finish. Use split-casting escutcheons if required, for existing piping.
  2. Un-insulated Piping Wall Escutcheons: Cast brass or stamped steel, with chrome-plated finish and set screw.
  3. Insulated Piping: Cast brass or stamped steel; with concealed hinge, spring clips, and chrome-plated finish.

### 3.05 SLEEVES / PENETRATIONS

- A. Sleeves are not required for core drilled holes through poured in place concrete walls.
- B. Install sleeves for pipes and ducts passing through masonry walls, gypsum-board partitions and concrete floor slabs.
- C. Cut sleeves to length for mounting flush with both surfaces when penetrating walls.
- D. Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
- E. Build sleeves into new walls and slabs as work progresses. Core drilling of poured in place concrete walls is acceptable.
- F. Install sleeves large enough to provide 1/4 inch (6.4 mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
  - 1. Steel Pipe Sleeves: For pipes smaller than 6 inch NPS (DN150).
  - 2. Steel, Sheet-Metal Sleeves: For pipes 6 inch NPS (DN150) and larger, penetrating gypsum-board partitions.
  - 3. Cast-iron "wall pipes" for sleeves 6 inches (150 mm) in diameter and larger.
  - 4. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
- G. When sleeve is installed in existing floor or masonry wall, seal space between sleeve and wall with non-shrink, nonmetallic grout.
- H. Above Grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants.
- I. Below Grade Exterior-Wall, Floors of Mechanical Spaces or other wet areas Pipe Penetrations: Seal penetrations using mechanical sleeve seals. Size for 1-inch (25-mm) annular clear space between pipe and opening for installing mechanical sleeve seals.
  - 1. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.
- J. Fire-Barrier Penetrations:
  - 1. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe and duct penetrations. Seal penetrations with fire sealants and caulks.
  - 2. This assembly must maintain a watertight seal between floor or wall and pipe when used on exterior walls, or floors of wet areas. Also use mechanical link seals in these cases.
  - 3. Use intumescent sealant for applications where combustible penetrants are involved (i.e., insulated or plastic pipe).
  - 4. Install in all penetrations where required by code.
- K. Sealant Application

1. Install sealants around all piping and duct penetrations.
2. Comply with sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
3. Sealant Installation Standard: Comply with recommendations of ASTM C 1193 for use of sealants as applicable to materials, applications, and conditions indicated.
4. Acoustical Sealant Application Standard: Comply with recommendations of ASTM C 919 for use of joint sealants in acoustical applications as applicable to materials, applications, and conditions indicated.
5. Install sealant backings of type indicated to support sealants during applications and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
  - a. Do not leave gaps between ends of sealant backings.
  - b. Do not stretch, twist, puncture, or tear sealant backings.
6. Install sealants by proven techniques to comply with the following and at the same time backings are installed:
  - a. Place sealants so they directly contact and fully wet joint substrates.
  - b. Completely fill recess between pipe and opening.
  - c. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
  - d. Remove excess sealants from surfaces adjacent to joint.
  - e. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of product in which joints occur.

### 3.06 PIPE IDENTIFICATION

- A. Install Pipe Identification on each system. Include pipe service as abbreviated on Drawings i.e. CHWS, CHWR, etc. and arrows showing normal direction of flow.
  1. Locate pipe identification as follows:
    - a. Exposed piping in unfinished spaces, machine rooms, and accessible maintenance spaces, such as shafts, tunnels, plenums, above lay-in ceilings and exterior non-concealed locations.
    - b. Near each branch, excluding short takeoffs for fixtures and terminal units. Mark each pipe at branch, if flow pattern or service is not obvious.
    - c. Adjacent to penetrations where pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.
    - d. At access doors, manholes and similar access points that permit view of concealed piping.
    - e. At all major equipment and other points of origination and termination.
    - f. Spaced at maximum of 50 foot (15 m) intervals along each run. Reduce intervals to 25 feet (7.5 m) in congested areas of piping and equipment and in equipment rooms.
- B. In all cases, Fire Protection and Natural Gas piping shall be painted in its entirety in all exposed areas including unfinished areas.

### 3.07 EQUIPMENT IDENTIFICATION

- A. Install engraved plastic-laminate sign on each scheduled piece of mechanical equipment.
  - 1. Lettering Size: Minimum 1/4 inch (6.4 mm) high lettering for name of unit if viewing distance is less than 24 inches (610 mm), 1/2 inch (12.7 mm) high lettering for distances up to 72 inches (1800 mm) and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principle lettering.
  - 2. Text of Signs: Provide specific name of unit as identified on Equipment Schedule on Drawings or as directed by the Owner. Inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
  - 3. Locate identifying devices as necessary for unobstructed view in finished construction.
  - 4. Where equipment is located above lay-in ceiling, affix a 1" adhesive label on ceiling grid system below equipment with equipment tag identification. Verify description requirements with Owner/Engineer. Where equipment is located above inaccessible ceilings, affix label or engraved plastic laminate sign securely to or near access panel.

### 3.08 PAINTING

- A. Use paint type and method of application as follows:
  - 1. Exterior Aluminum Rooftop Equipment: Factory applied Kynar, Dark Bronze.
- B. Do not paint piping specialties with factory-applied finish.
- C. Adhere strictly to paint manufacturer's written instructions for application.
- D. Damage and Touch-Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- E. Paint the following:
  - 1. All exposed insulated and or uninsulated pipes, equipment, ductwork including insulation, etc. in finished areas.
  - 2. All exposed ventilation equipment and ductwork in finished areas.
  - 3. All equipment located in boiler room or equipment spaces.
  - 4. All exposed bare pipe.
  - 5. All hangers, platforms, supports and miscellaneous steel.
  - 6. All exterior galvanized iron steel surfaces, including cooling towers, rooftop units, piping ventilators, intake cowls, wall frames, louvers, exhaust vents, boiler stack and other miscellaneous surfaces.
  - 7. All sheet metal pipe enclosures in finished spaces to be painted to match adjacent surfaces.
  - 8. Convactor cabinets, fin pipe enclosures and cabinet unit heaters.
  - 9. All supply, return and exhaust grilles painted to match adjoining surfaces.
  - 10. All roof mounted ventilation equipment.
  - 11. All access panels.

3.09 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit and place miscellaneous metal supports accurately in location, alignment and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS D1.1, "Structural Welding Code – Steel".

3.010 HOUSEKEEPING PADS

- A. Install housekeeping pads below all equipment located in Mechanical Room.
- B. Pads shall be constructed of poured-in-place concrete, Nominal 6" thick (form using standard 2" x 6" lumber) with 1" chamfer on all horizontal edges.
- C. Pads shall extend a minimum of 6" beyond equipment in all directions or as detailed on the Drawings.

3.011 GROUTING

- A. Install nonmetallic, non-shrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout. To ensure complete grout base, with no voids, pack grout from one side until grout is forced out of opposite side of base.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases to provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout according to manufacturer's written instructions.

3.012 EXCAVATION AND BACKFILLING

- A. Properly support banks of excavation with safety sheet pile. Install barricades, fences, guards, etc. as required for safety and by OSHA.
- B. Provide adequate pumping equipment and keep excavation free of water.
- C. Excavate pipe trenches to proper depth and slope as required for piping
- D. Pipes passing under or through footings shall be sleeved (minimum two pipe sizes larger than pipe).

- E. Pipes passing under or through corrosive fills shall have external coating to protect from corrosion.
- F. Support and protect underground piping so it remains in place without settling and without damage during and from backfilling. Replace any piping so settled or damaged. Pipe shall not be supported on blocks to grade.
- G. Lay underground piping on 6" bed of sand. Sand to fill from trench bottom to 6" above top of pipe. Carefully fill sand around pipe being sure that there is a complete smooth layer below pipes with no voids.
- H. Backfill with clean earth, crushed rock, gravel or sand. Use only sand inside buildings. Fill first two feet in 6" lifts and remainder in 12" lifts. Tamp and puddle each layer
- I. Provide 6" wide marker tape buried directly underground above utility lines continuously along length of pipe. Marker tape shall be a minimum of 12" above utility line. Marker tape shall be a minimum of 6" wide.
- J. Replace all surfaces with like, kind, i.e. grass, road, sidewalk, etc., or as specified elsewhere.

### 3.013 THERMOSTATS AND SENSORS

- A. Unless specifically noted otherwise, install all wall mounted thermostats and sensors required for respective equipment with top of rough-in box elevation at 48" A.F.F. Close coordinate rough-in locations with all trades.

END OF SECTION 200050

SECTION 200060 – COMMON PIPE, VALVES & FITTINGS FOR FIRE SUPPRESSION, PLUMBING & HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This section specifies piping, valves and fittings including piping support for all systems. These systems include the following:
  - 1. System Piping Schedule #1
    - Heating Water
    - Chilled Water
  - 2. System Piping Schedule #3
    - 0 to 15 PSIG Steam Supply
  - 3. System Piping Schedule #4
    - 16 to 100 PSIG Steam Supply
  - 4. System Piping Schedule #5
    - 101 to 150 PSIG Steam Supply
  - 5. System Piping Schedule #8
    - Steam Condensate
    - Steam Blowoff
    - Steam Relief
  - 6. System Piping Schedule #9
    - High Pressure Steam Condensate
    - High Pressure Steam Blowoff
    - High Pressure Steam Relief
  - 7. System Piping Schedule #13
    - Coil Condensate
  - 8. System Piping Schedule #14
    - Sanitary Inside Building
    - Vent Inside Building
    - Storm Gravity Inside Building
  - 9. System Piping Schedule #15
    - Sanitary Outside Building
    - Vent Outside Building

Storm Gravity Outside Building

10. System Piping Schedule #16  
Sanitary Forced Main  
Storm Forced Main
11. System Piping Schedule #17  
Domestic Hot Water Aboveground  
Domestic Cold Water Aboveground
12. System Piping Schedule #19  
Fire Protection

B. All specialty valves for specific systems are listed in specification sections for those systems. Specialty valves for specific systems can be found in the following sections:

1. Plumbing Specialty Valves – 22 00 00 “Plumbing”
2. Fire Protection Specialty Valves – 21 00 00 “Fire Protection”
3. Refrigeration Specialty Valves – 23 00 00
4. Hydronic Specialty Valves – 23 00 00 “Heat Transfer”
5. Control Valves – 23 00 00 “Temperature Controls”

C. Related sections include the following:

1. 20 00 10 Common Work Results for Fire Suppression, Plumbing and HVAC
2. 20 00 50 Common Materials and Methods for Fire Suppression, Plumbing and HVAC
3. 20 01 80 Common Insulation for Plumbing and HVAC
4. 21 00 00 Fire Suppression
5. Division 22 Plumbing
6. Division 23 Mechanical

1.03 SUBMITTAL

- A. Submit product data for valves and fittings used in each system.
- B. Submittal data to be in compliance with Section 20 00 10.
- C. Product data shall include pressure and temperature classifications, model numbers, material types, actuators, trim, valve handle extensions and all pertinent data as required for complete evaluation by Engineer.
- D. Maintenance data for valves shall include adjusting, servicing, disassembly, exploded view with part numbers and repair instructions.
- E. Piping submittals are not required. However piping to meet all specifications.

1.04 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

- B. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.
- C. All grooved joint couplings, fittings, valves and specialties shall be products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
- D. Welded and Soldered Pipe
  - 1. Pipe welding shall comply with provisions of latest revision of applicable code, whether ASME Boiler & Pressure Vessel Code, ASTM Code for Pressure Piping, or such state or local requirements as may supersede code mentioned above.
  - 2. A copy of his welding procedure specification together with proof of its qualification as outlined and required by most recent issue of code having jurisdiction.
  - 3. Submit Operator's qualification record in conformance with provisions of code having jurisdiction, showing that operator was under proven procedure specifications submitted by Contractor.
  - 4. Standard procedure specifications and operators qualified by National Certified Pipe Welding Bureau shall be considered as conforming to requirements of these specifications.
  - 5. Welders to have ASME test papers not more than 5 years old.
  - 6. Each manufacturer or Contractor shall be responsible for quality of welding done by his organization and shall repair or replace work not in accordance with these specifications.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Prepare for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, grooves, and weld ends.
  - 3. Set globe and gate valves closed to prevent rattling.
  - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
  - 5. Set butterfly valves closed or slightly open.
  - 6. Set butterfly valves closed or slightly open.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
  - 3. Stack piping above grade and covered.
- C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use handwheels and stems as lifting or rigging points.

## PART 2 - PRODUCTS

### 2.01 PIPE MATERIAL DESIGNATIONS

- A. Refer to System Schedules in Execution portion of this Section for designation of pipe types to be used for each piping system. When more than one piping type is designated, contractor may choose which type is installed.
- B. Piping Designations
  - 1. CP-2 Steel:
    - a. 3/4" to 2" ASTM A53, Type S (seamless) or Type F (furnace-butt welded) Grade A Black steel (galvanized if so noted). U.S. Steel; Laclede; Republic; Youngstown, Jones & Laughlin.
    - b. 2-1/2" to 12" ASTM A53, Type E (electric resistance welded) Grade A Black steel (galvanized if so noted).
    - c. 14" to 20" ASTM A53, Type E (electric resistance welded) Grade B or Type S (seamless), (galvanized if so noted). U.S. Steel; Laclede; Republic; Youngstown; Jones & Laughlin.
  - 2. CP-7 DWV Copper Tube: ASTM B306, Drawn Temper.
  - 3. CP-8 Copper: ASTM B75, B88, B251 and B447; ASA H23.1-1947 seamless copper tubing, hard temper (soft copper if so noted). Type K or L. (as noted) Chase; Bridgeport, Anaconda; Scovill.
  - 4. CP-20 Ductile Iron Mechanical Joint: AWWA C151 with Mechanical Joint Bell and plain spigot end, cast iron pipe, centrifugally cast with asphaltum coating. Class as noted in schedule. Pipe to be marked and carry nominal weights and dimensions as required by state and local codes. As manufactured by James B. Clow & Sons; American Cast Iron Pipe; Alabama Pipe; U.S. Pipe & Foundry.
  - 5. CP-30 PVC: polyvinylchloride; ASTM D 1785 schedule as noted. As manufactured by A.M. Byers; U.S. Steel; Carlon, Crescent; **normal or high impact as noted**.
  - 6. CP-32 PVC SDR 35: (4" to 15") Polyvinylchloride Pipe, Type PSM conforming to ASTM D 3034. Reworked material is not acceptable. Cell Classification of 12454-B as defined in ASTM D 1782 and SDR (standard dimension ratio) of not greater than 35.
  - 7. CP-33 PVC DWV Drainage Pipe: ASTM D2665, Polyvinylchloride pipe solid-wall, waste, and vent. Schedule as noted.
  - 8. CP-34 ABS Pipe: ASTM D 2661, Solid Wall.
  - 9. CP-40 Cast Iron (HUB) Bell and Spigot: ASTM A74, extra heavy bell and spigot cast iron soil pipe centrifugally metal or sand spun cast with asphaltum coating. American Brass & Iron; Tyler; Charlotte. Pipe and fittings shall be labeled with the trademark of the Cast Iron Soil Pipe Institute.
  - 10. CP-41 Soil Pipe: Cast Iron no hub ASTM A888, CISPI 301. No hub cast iron soil pipe centrifugally metal or sand spun cast with asphaltum coating. American Brass & Iron;

Tyler; Charlotte. Pipe and fittings shall be labeled with the trademark of the Cast Iron Soil Pipe Institute.

## 2.02 PIPE FITTING DESIGNATIONS

- A. Refer to System Schedules in Execution portion of this Section for designation of fitting types to be used for each piping system. Fittings to be of the same strength of piping in each respective piping system. When more than one type is designated, contractor may choose which type is installed.
- B. Fitting Designations:
1. CF-1 Malleable Iron: ASME B16.3. 300# (or as noted) black band malleable iron threaded fitting (galvanized if so noted). Grinnell; Flagg; Kuhns; Illinois Malleable; Stockham.
  2. CF-2 Cast Iron: ASME B16.4; 250# (or as noted) black cast iron threaded fitting (galvanized if so noted). Grinnell; Kuhns; Illinois Malleable; Stockham.
  3. CF-4 Flanged: 125# (or as noted) black cast iron, flanged fitting (galvanized if so noted). Grinnell; Kuhns; Stockham; Illinois Malleable.
  4. CF-5 Wrought Steel fittings: ASTM, B16.9, B16.11, B16.28. Steel butt welding fitting. All elbows shall be long radius, unless otherwise noted. Tube Turns; Midwest; Taylor Forge; Ladish; NIBCO; Grinnell; Weld Bend; Babcock Wilcox.
  5. CF-6 Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47 (ASTM A 47M), Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings. All fittings shall be long radius unless otherwise specified. UL listed, FM approved for fire service. Victaulic; Anvil; Gruvlok.
  6. CF-8 Wrought Copper: ASME B16.22. Wrought copper solder joint fitting as manufactured by Flagg; Mueller; Chase, NIBCO; Anaconda; American Brass.
  7. CF-8A Wrought Copper Cold Press Fitting: Fitting specifically design to be field installed with hand held portable press tool. Fitting to be certified by NSF, UL and be compliant with ICC, UPC, PHCC, NFPA13, 13D and 13R. Fittings to be ProPress Smart Connect installed by RIGID Portable Press tool.
  8. CF-10 Cast Brass: cast brass solder joint as manufactured by Flagg; Mueller; Chase; NIBCO; Anaconda.
  9. CF-11 Copper Drainage: ASME B16.23 cast copper, or ASME B16.29 wrought copper, type DWV as manufactured by Flagg; Mueller; Chase, NIBCO; Anaconda.
  10. CF-20 Mechanical Joint: AWWA C111 ductile or grey-iron, standard pattern, same class as noted for pipe. Alabama Pipe, U.S. Pipe & Foundry.

11. CF-30 PVC: Polyvinylchloride; same schedule and impact as noted. Schedule 40 ASTM D 2466 Socket Type, Sch 80 ASTM D 2467 Socket. Carlon; Crescent; A.M. Byers; U.S. Steel; Chemtrol.
12. CF-32 PVC Drainage Fitting: ASTM D 3034, SDR 35 for gasketed joints.
13. CF-33 PVC Drainage Fittings: ASTM D2665, socket type, made to ASTM D 3311 drain waste and vent patterns.
14. CF-34 ABS Drainage: ASTM D 2661, made to ASTM D 3311, drain, waste and vent pattern socket fittings.
15. CF-40 (HUB) Bell and Spigot: Cast iron bell and spigot Type fitting DWV configuration, extra heavy duty. American Brass & Iron; Tyler; Charlotte.
16. CF-41 (NO-HUB) Mechanical Joint: Cast iron no hub type fitting - DWV configuration. American Brass & Iron; Tyler; Charlotte.
17. CF-43 Ductile Iron Fitting: AWWA C 110, ductile or grey iron, for push on joints.

## 2.03 PIPE JOINT DESIGNATIONS

- A. Refer to System Schedules in Execution portion of this Section for designations of joint types to be used for each piping system. When more than one type is designated, contractor may choose which type is installed.
- B. Piping Joint Designations:
  1. CJ-1 Threaded: threads shall conform to ASME B1.20.1, ASTM B16.3, B16.4, B16.12. Remove all burrs. Ream pipe ends to full bore and remove all chips. Use pipe compound on male ends only. Approved pipe compounds: Blue Seal; Key Tite.
  2. CJ-5 Welded Pipe: standard specification provision for fabrication and erection of piping systems as recommended by National Certified Pipe Welding Bureau. All welding of pipe, regardless of condition of is to be installed as follows:
    - a. Pipe welding shall comply with provisions of latest revision of applicable code, whether ASME Boiler & Pressure Vessel Code, ASTM Code for Pressure Piping, or such state or local requirements as may supersede code mentioned above.
    - b. A copy of his welding procedure specification together with proof of its qualification as outlined and required by most recent issue of code having jurisdiction.
    - c. Submit Operator's qualification record in conformance with provisions of code having jurisdiction, showing that operator was under proven procedure specifications submitted by Contractor.
    - d. Standard procedure specifications and operators qualified by National Certified Pipe Welding Bureau shall be considered as conforming to requirements of these specifications.
    - e. Welders to have ASME test papers not more than 5 years old.
    - f. Each manufacturer or Contractor shall be responsible for quality of welding done by his organization and shall repair or replace work not in accordance with these specifications.

3. CJ-6: grooved mechanical-joint couplings: Two ductile or iron housing segments and synthetic rubber EPDM (+250°F) gasket of central cavity pressure-response design; with ASTM A449 nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings; Victaulic Installation-Ready Style 107H rigid coupling, or equal by Anvil or Gruvlok. UL classified in accordance with ANSI / NSF-61 for potable water service and shall meet the low-lead requirements of NSF-372. Tongue and recess couplings may only be used if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufactures latest recommendations and each coupling shall be tagged or marked with indelible ink indicating the specific value of torque attained to confirm joint rigidity and proper installation.
4. CJ-8: 95% tin, 4.85% copper, 0.15% selenium. Premium Contractor Grade solder. 410°F Minimum working temperature; 7130 PSI Tensile Strength, ASTM B32. Like Taramet Sterling, Taracorp. IMACO, Winston-Salem, NC. Cut ends of tubing square with wheel type cutter, ream to remove burrs, wipe clean on inside, apply paste type solder flux on external surface. Apply solder (no lead allowed).
5. CJ-8A: Cold Press connection 0-250°F, 200 psig. Connection made using a hand held portable press system. Joint to be certified by NSF, UL and be compliant with ICC, UPC, PHCC, NFPA13, 13D and 139 like RIGID VIEGA ProPress System.
6. CJ-20 Mechanical Joint: AWWA C 111 ductile - or grey - iron glands, rubber gasket and steel bolts. Reinforce joint at hydrants, fittings or valves with heavy wrought iron clamps and wrought iron rods in accordance with standard details of National Board of Fire Underwriters. Apply heavy coat of bituminous solution to assembly.
7. CJ-32 Gasket for PVC Sewer pipe: ASTM F 477 elastomeric seals.
8. CJ-33 PVC
  - a. Solvent Cement: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    - 1) Comply with ASTM F 402 for safe-handling practice of cleaners, primers and solvent cements.
    - 2) ABS piping: ASTM D 2235 and ASTM D 2661.
    - 3) CPVC Piping: ASTM D 2846 and ASTM F-493.
    - 4) PVC Pressure Piping: ASTM D 2672.
    - 5) PVC Nonpressure Piping: ASTM D 2665.
    - 6) PVC to ABS Nonpressure Transition Fittings: Procedure and solvent cement according to ASTM D 3138.
  - b. Heat Welding: ASTM D 2657
  - c. Threads: Use only where noted on schedules. Install as outlined for steel pipe but only to be used on Schedule 80 or 120 pipe. Use strap wrench for tightening.
9. CJ-40 (HUB) Bell & Spigot: Gasket-ASTM C 564, Rubber. American Brass & Iron; Tyler; Charlotte.
10. CJ-41 (No HUB) Coupling: Stainless steel couplings CISPI 310 with ASTM A 167, Type 301 or ASTM A 666 Type 301 Stainless steel corrugated shield; stainless steel bands and sleeve. American Brass & Iron; Tyler; Charlotte.

11. CJ-43 Wrought Cast-and Forged-Steel Flanges and Flanged Fittings: Class 150 and 300 ASME B16.5, including bolts, nuts, and gaskets of Materials Group: 1.1, Connections Butt Weld, facings: Raised Face; Crane.
12. CJ-44 Flanged Joints:
  - a. Cast-Iron Flanges and Flanged Fittings: ASME B16.21, Classes 25, 125 and 250; raised ground face, and bolt holes spot faced. Including bolts, nuts and gaskets.
  - b. Flange bolts and nuts: ASME B18.2, Carbon Steel unless otherwise indicated.
13. CJ-45 Mechanical Grooved Pipe Couplings: Style 107/ W07 rigid couplings, Style 177/ W77 standard couplings. Installation and pipe grooving shall be in accordance with manufacturer's instructions. Coupling shall be suitable for working pressure and temperature of service. Coupling shall be approved by authorities having jurisdiction. Unions and flanges for servicing and disconnect are not required in installations with grooved mechanical joint couplings. The couplings shall serve as disconnect points.
  - a. Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings shall comply with ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
  - b. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, with Victaulic Style 107H/107N (Quick-Vic™) or GruvLok SlideLok, Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).
  - c. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source. Victaulic Style 177 (Quick-Vic™) or GruvLok, Installation ready or Style 77 flexible coupling.
  - d. Victaulic AGS Mechanical Couplings, 14 inch (DN350) through 60 inch (DN1500): Couplings shall consist of two ASTM A-536 ductile iron housing segments with lead-in chamfer on housing key and a wide-width elastomer pressure responsive gasket. Victaulic Style W07 AGS Rigid and Style W77 AGS Flexible Coupling.

## 2.04 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings: CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
  1. Manufacturers:
    - a. Eslon Thermoplastics.
- B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimension; one end with threaded brass insert, and one solvent-cement-joint end.
  1. Manufacturers:

- a. Thomson Plastics, Inc.
  - C. Plastic-to-Metal Transition Unions: MSS SP-107, PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
    - 1. Manufacturers:
      - a. NIBCO, Inc.; Chemtrol Div.
- 2.05 DIELECTRIC FITTINGS
- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
  - B. Insulating Material: Suitable for system fluid, pressure and temperature.
  - C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
    - 1. Manufacturers:
      - a. Capitol Manufacturing Co.
      - b. Central Plastics Company/
      - c. Eclipse, Inc.
      - d. Epco Sales, Inc.
      - e. Hart Industries, International, Inc.
      - f. Watts Industries, Inc.; Water Products Div.
      - g. Zurn Industries, Inc.; Wilkins Div.
  - D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300- psig minimum working pressure as required to suit system pressures.
    - 1. Manufacturers:
      - a. Capitol Manufacturing Co.
      - b. Central Plastics Company
      - c. Epco Sales, Inc.
      - d. Watts Industries, Inc.; Water Products Div.
  - E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
    - 1. Manufacturers:
      - a. Advance Products & Systems, Inc.
      - b. Calpico, Inc.
      - c. Central Plastics Company
      - d. Pipeline Seal and Insulator, Inc.
    - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

- F. Dielectric Couplings: Galvanized-steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

- a. Calpico, Inc.
- b. Lochinvar Corp.

- G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

- a. Perfection Corp.
- b. Precision Plumbing Products, Inc.
- c. Sioux Chief Manufacturing Co., Inc.
- d. Victaulic Co. of America

## 2.06 UNIONS AND FLANGED CONNECTIONS

- A. 150 pound malleable iron with ground joint and brass to iron seats. Crane 1280.
- B. 125 pound wrought copper or cast brass union with solder joint fittings. Crane 633.
- C. 150 pound forged steel flanges with welding neck. Crane 568.
- D. 150 pound bronze flanges with tube stop. Mueller F900.

## 2.07 VALVE DESIGNATIONS

- A. Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- B. All valves shall be compatible with the type of piping material installed in the system.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-1 CV-2
- 3 TYPE Gate Gate
- 4 MAXIMUM WORKING
- 4.1 Pressure - PSIG 125 125
- 4.2 Temperature - °F Sat. Stm. Sat. Stm.
- 5 SIZE LIMITS - Inches 1/2 - 3 2 1/2 - 12
- 6 DESCRIPTION
- 6.1 Body Bronze Iron ASTM A-126B
- 6.2 Trim Bronze Bronze
- 6.3 Gate Split Wedge Solid ASTMA-126B
- 6.4 Bonnet Screw-in Bolted
- 6.5 Stem Rising OS&Y ASTM B-16B
- 6.6 Seat Integral Renewable
- 6.7 Agency Compliance MSS SP-80 MSS SP-70
- 7 APPROVED RODUCTS
- 7.1 Nibco S211, T211, T135 F617-0
- 7.2 Jenkins 991 AT, 990 AJ 651A, 650A
- 7.3 Crane 1700S, 1700T 465 - 1/2
- 8 NOTES
- 8.1 Use OS&Y (CV-2) valves when noted on drawings.
- 8.2 Provide manufacturer's standard stem packing for service intended.
- 8.3 Valves with rising stems suitable for repacking under pressure.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-3.1
- 3 TYPE Gate
- 4 MAXIMUM WORKING
- 4.1 Pressure - PSIG 250
- 4.2 Temperature - °F 450
- 5 SIZE LIMITS - Inches 2 1/2 - 12
- 6 DESCRIPTION
- 6.1 Body Cast Iron or Ferrosteeel
- 6.2 Trim Bronze
- 6.3 Disc/plug Solid Wedge
- 6.4 Bonnet Bolted
- 6.5 Stem OS&Y
- 6.6 Seat Renewable rings
- 7 APPROVED PRODUCTS
- 7.1 Crane 7-1/2E
- 7.2 Lunkenheimer 1436
- 7.3 Jenkins 204
- 7.4 Stockham F667
- 8 NOTES
- 8.1 Provide manufacturer's standard stem packing for service intended.
- 8.2 Valves with rising stems suitable for repacking under pressure.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-1.4
- 3 TYPE Gate
- 4 MAXIMUM WORKING
- 4.1 Pressure - PSIG 600
- 4.2 Temperature - °F 850
- 5 SIZE LIMITS - Inches 1/2 - 2"
- 6 DESCRIPTION
- 6.1 Body Forged Steel
- 6.2 Trim Monel
- 6.3 Disc/plug Solid
- 6.4 Bonnet Bolted
- 6.5 Stem OS&Y
- 6.6 Seat Renewable
- 6.7 Agency Compliance ASME B16.34, API 602
- 7 APPROVED PRODUCTS
- 7.1 Vogt SW12111 (Socket Weld)
- 8 NOTES
- 8.1 Provide manufacturer's standard stem packing for service intended.
- 8.2 Valves with rising stems suitable for repacking under pressure.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

1	Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.		
2	VALVE DESIGNATION	CV-4	
3	TYPE	Globe	
4	MAXIMUM WORKING		
4.1	Pressure - PSIG	125	
4.2	Temperature - °F	Sat. Stm.	
5	SIZE LIMITS - Inches	1/2 - 2 1/2	
6	DESCRIPTION		
6.1	Body	Bronze	
6.2	Trim	Bronze	
6.3	Disc/plug	Renewable Composite	
6.4	Bonnet	Screw-in	
6.5	Stem	Rising-Silicon Bronze	
6.6	Seat	Integral	
6.7	Agency Compliance	MSS SP-80	
	APPROVED PRODUCTS	Soldered	Threaded
7.1	Nibco	S211	T211
7.2	Crane	1310	1
8	NOTES		
8.1	Provide manufacturer's standard stem packing for service intended.		
8.2	Valves with rising stems suitable for repacking under pressure.		

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-5 CV-6
- 3 TYPE Globe Angle
- 4 MAXIMUM WORKING
- 4.1 Pressure - PSIG 125 125
- 4.2 Temperature - °F Sat. Stm. Sat. Stm.
- 5 SIZE LIMITS - Inches 3 - 12 3 - 12
- 6 DESCRIPTION
- 6.1 Body Iron ASTM A126 Iron
- 6.2 Trim Bronze ASTM B-584
- 6.3 Disc/plug Renewable Composite Renewable Composite
- 6.4 Bonnet Bolted Bolted
- 6.5 Stem OS&Y OS&Y
- 6.6 Seat Renewable Rings Renewable Rings, ASTM B584
- 6.7 Agency Compliance MSS SP-85 MSS SP-85
- 7 APPROVED PRODUCTS
- 7.1 Nibco F-718-B F-818-B
- 7.2 Crane 351 353
- 7.3 Jenkins 613CJ 615CJ
- 8 NOTES
- 8.1 Provide manufacturer's standard stem packing for service intended.
- 8.2 Valves with rising stems suitable for repacking under pressure.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-4.1 CV-5.1
- 3 TYPE Globe Globe
- 4 MAXIMUM WORKING
- 4.1 Pressure - PSIG 150 150
- 4.2 Temperature - °F 300 300
- 5 SIZE LIMITS - Inches 1/2 - 3 2 1/2 - 8
- 6 DESCRIPTION
- 6.1 Body Bronze Cast Steel
- 6.2 Trim Screwed Bronze Exelloy
- 6.3 Disc/plug Renewable Plug Renewable Plug
- 6.4 Bonnet Union Bolted
- 6.5 Stem Rising OS&Y
- 6.6 Seat Renewable Renewable
- 7 APPROVED PRODUCTS
- 7.1 Crane 14 - 1/2P 143XR (Flange)  
143 -1/2 XR (Weld)
- 7.2 Jenkins 546P 1040-CM  
2040-CM
- 7.3 O.I.C. 559 1542-N
- 8 NOTES
- 8.1 Provide manufacturer's standard stem packing for service intended.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

1	Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.			
2	VALVE DESIGNATION	CV-7	CV-8	
3	TYPE	Horizontal Swing Check	Horizontal Swing Check	
4	MAXIMUM WORKING			
4.1	Pressure - PSIG	125	125	
4.2	Temperature - °F	Sat. Stm.	Sat. Stm.	
5	SIZE LIMITS - Inches	0 - 3	2 1/2 - 12	
6	DESCRIPTION			
6.1	Body	Bronze ASTM-B62	Iron ASTM A-126	
6.2	Trim	Bronze	Bronze	
6.3	Disc/plug	Bronze	Renewable Bronze	
6.4	Bonnet	Screw-in	ASTM B-584	
6.5	Seat	Integral	Renewable Rings	
6.6	Agency Compliance	MSS SP-80	MSS SP-71 TYPE I	
7	APPROVED PRODUCTS	Soldered	Threaded	Threaded Flanged
7.1	Crane	1342	37	372 373
7.2	Nibco	S41BB	T-413B	T-918-13 F-918-13
7.3	Jenkins	762A		
7.4	Victaulic	Series 716		Series 779

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-9
- 3 TYPE Non-Slam Wafer Check
- 4 MAXIMUM WORKING
  - 4.1 Pressure - PSIG 150 (WOG)
  - 4.2 Temperature - °F 100
- 5 SIZE LIMITS - Inches 2 - 12
- 6 DESCRIPTION
  - 6.1 Body Semi-Steel, ASTM A-126
  - 6.2 Trim Bronze ASTM B-62
  - 6.3 Disc/plug Center Guided
  - 6.4 Bonnet
  - 6.5 Seat Renewable Rings
  - 6.6 Agency Compliance
- 7 APPROVED PRODUCTS
  - 7.1 Crane 1400
  - 7.2 Lunkheimer -
  - 7.3 Nibco W910
  - 7.4 Mueller 91 AP, 92 AP
  - 7.5 Victaulic Series 779

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- |     |  |                            |
|-----|--|----------------------------|
| 1   | Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system. |                            |
| 2   | VALVE DESIGNATION  | CV-15                      |
| 3   | TYPE   | Globe<br>Non-Slam<br>Check |
| 4   | MAXIMUM WORKING  |                            |
| 4.1 | Pressure - PSIG  | 125                        |
| 4.2 | Temperature - °F   | 200                        |
| 5   | SIZE LIMITS - Inches   | 4 - 12                     |
| 6   | DESCRIPTION  |                            |
| 6.1 | Body   | Cast Iron                  |
| 6.2 | Trim   | Bronze                     |
| 6.3 | Disc/plug  | Center Guided              |
| 6.4 | Bonnet   |                            |
| 6.5 | Seat   | Bronze                     |
| 7   | APPROVED PRODUCTS  |                            |
| 7.1 | Nibco  | <b>F-910</b>               |
| 7.2 | Mueller  | <b>105M-AP</b>             |
| 8   | NOTES  |                            |
| 8.1 | Use lift check valves only when noted on Drawings.   |                            |
| 8.2 | Use viton seat on CV-15 for temperatures above 250°F.  |                            |

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- |       |   |   |
|-------|---|---|
| 1     | Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.                            |   |
| 2     | CLASS NO.   | CV-20   |
| 3     | TYPE  | Ball - Full Port  |
| 4     | MAXIMUM WORKING   |   |
| 4.1   | Pressure - PSIG   | 600   |
| 4.2   | Temperature - °F  | Sat. Stm.   |
| 5     | SIZE LIMITS - Inches  | 1/2 – 2 1/2"  |
| 6     | DESCRIPTION   |   |
| 6.1   | Body/End Piece  | 2-Piece Construction - ASTM B 584 Bronze Body Alloy 844<br>Forging Brass ASTM B-124 Alloy 377 |
| 6.2   | Ball  | Chromeplated Brass Conventional Port  |
| 6.3   | Stem  | Bronze or Brass   |
| 6.3.1 |   | Provide with Stem Extension on insulated pipes  |
| 6.4   | Seats/Seals   | Teflon  |
| 6.5   | Agency Compliance   | MSS SP-110  |
| 7     | APPROVED PRODUCTS   |   |
| 7.1   | Nibco   | T-585-70  |
| 7.2   | Crane/Capri   | 9202  |
| 7.3   | Conbraco Industries, Inc.   | 70-100  |
|       | Apollo Series   |   |
| 8     | NOTES   |   |
| 8.1   | Soldered valves are not allowed.  |   |
| 8.2   | Provide stem extension or valve manufacturers insulated extension handle system on all valves installed in insulated systems and specified to be insulated. |   |

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 VALVE DESIGNATION CV-21.3
- 3 TYPE Ball - Full Port
- 4 MAXIMUM WORKING
  - 4.1 Pressure - PSIG 300
  - 4.2 Temperature - °F 600
- 5 SIZE LIMITS - Inches 2 1/2 - 10
- 6 DESCRIPTION
  - 6.1 Body/End Piece Cast Steel Flanged, A216 Gr WCB, One Piece
  - 6.2 Ball A 351 Gr CF8M
  - 6.3 Stem AISI 316
  - 6.4 Seats Tru-Therm 99
  - 6.5 Agency Compliance
  - 6.6 Handle Gear actuator  
larger
- 7 APPROVED PRODUCTS
  - 7.1 True-Line LCV – 300 Figure 330
- 8 NOTES
  - 8.1 Stem extension for all insulated pipes.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

- 1 Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.
- 2 CLASS NO. CV-23
- 3 TYPE Butterfly
- 4 MAXIMUM WORKING
  - 4.1 Pressure - PSIG 300
  - 4.2 Temperature - °F 200
- 5 SIZE LIMITS - Inches 3 – 6 (see note below)
- 6 DESCRIPTION
  - 6.1 Body/End Piece Duct. Iron ASTM A-126 Threaded Lug for dead end service
  - 6.2 Disc AL. Bronze ASTM B-148 Alloy 954/955; Coated Ductile Iron
  - 6.3 Stem 416 Stainless steel ASTM A-582  
Collar bushings upper and lower bushing  
Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating.
  - 6.4 Seats Pressure Responsive EPDM
  - 6.5 Agency Compliance MSS SP-67
- 7 OPERATOR
  - 7.1 Standard Lever-lock handle w/memory stop
- 8 APPROVED PRODUCTS
  - 8.1 Nibco LD 2000-3
  - 8.2 Crane 14-TL
  - 8.3 Apollo 6L-31
  - 8.4 Lunkenheimer FIG. 4735
  - 8.5 Stockham LD-711-BS3-E
  - 8.6 Victaulic VIC300 Series
- 9 NOTES
  - 9.1 Do not use butterfly valves on pipes size 2 1/2" and smaller.

PART 2 - PRODUCTS (Continued)

VALVE SCHEDULES

1	Refer to System Schedules in Execution portion of this Section for designation of valve types to be used for each piping system.		
2	VALVE DESIGNATION	CV-26	CV-27
3	TYPE	Blowoff	Blowoff
4	MAXIMUM WORKING		
4.1	Pressure - PSIG	250	250
4.2	Temperature - °F	450	450
5	SIZE LIMITS - Inches	1 ½ – 2 (Screwed)	1 ½ – 2 ½ (Screwed)
6	DESCRIPTION		
6.1	Body	Iron	Iron
6.2	Trim	Bronze	Bronze
6.3	Disc and Packing Manufacturer's Standard		
6.4	All Parts Renewable		
7	APPROVED PRODUCTS		
7.1	Crane	393	393-1/2
7.2	Lunkenheimer	1351	1352
7.3	Walworth	180	
7.4	Powell	544	545
7.5	Or approved equal		
8	NOTES		
8.1	ASME approved for intended use.		

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install pipe, valves and fittings for each system as designated in the System Schedules on the following pages.
- B. Reference Products, Part 2 of this Section for specifications and manufacturers of pipes, valves and fittings designated to be installed in System Schedules.

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 1  
HEATING & CHILLED

1	Install pipe, valves and fittings as designated in this Schedule for this System.			
2	NOMINAL SIZE RANGE			
2.1	Minimal Diameter	1/2"	2 1/2"	10"
2.2	Maximum Diameter	2"	8"	20"
3	DESIGN			
3.1	Working Pressure PSIG	160	160	160
3.2	Working Temperature °F	250	250	250
4	PIPING MATERIAL DESIGNATIONS			
4.1	Soft "K" Copper (See Notes)	CP-8	-	-
4.2	Hard "L" Copper	CP-8	CP-8	-
4.3	Sch. 40 Bl. St. (See Notes)	CP-2	CP-2	CP-2
5	FITTING DESIGNATIONS			
5.1	Cold Press	CF-8A	CF-8A	-
5.2	Wrought	CF-8-	CF-8-	-
5.3	Cast Iron Threaded	-	-	-
5.4	Flanged	-	CF-4	CF-4
5.5	Butt Welded	-	CF-5	CF-5
5.6	Grooved	-	CF-6	CF-6
6	JOINT DESIGNATIONS			
6.1	Cold Press	CJ-8A	CJ-8A	-
6.2	Solder	CJ-8	CJ-8	-
6.3	Threaded	-	-	-
6.4	Welded	-	CJ-5	CJ-5
6.5	Flanged 125#	-	CJ-44	CJ-44
6.6	Grooved	-	CJ-45	CJ-45
7	VALVE DESIGNATIONS			
7.1	Ball	CV-20	CV-20	-
7.2	Butterfly	-	CV-23, 24	CV-24, 25
7.3	Globe	CV-4	CV-4, 5	CV-5
7.4	Wafer Check	-	CV-9	CV-9
7.5	Globe Check	-	CV-15	CV-15
8	NOTES			
8.1	Pipe installed below grade shall be continuous soft copper. No piping joints allowed below grade. All pipes above grade shall be straight lengths.			
8.2	Use Schedule 30 black steel pipe on all sizes 12" and over.			
8.3	Use 1/2" pipe only if shown on Drawings.			

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 3  
0 to 15 PSIG STEAM SUPPLY

1	Install pipe, valves and fittings as designated in this Schedule for this System.		
2	NOMINAL SIZE RANGE		
2.1	Minimum Diameter	3/4"	2 1/2"
2.2	Maximum Diameter	2"	12"
3	DESIGN		
3.1	Working Pressure PSIG	125	125
3.2	Working Temperature °F	250	250
4	PIPING DESIGNATIONS		
4.1	Sch. 40 Bl. St.	CP-2	CP-2
5	FITTING DESIGNATIONS		
5.1	Cast Iron Threaded	CF-2	-
5.2	125# Cast Iron Flanged	-	CF-4
5.3	Sch. 40 Wrt. St.	-	CF-5
6	JOINT DESIGNATIONS		
6.1	Threaded	CJ-1	-
6.2	Butt Welded	-	CJ-5
6.3	125# Flanged	-	CJ-44
7	VALVE DESIGNATIONS		
7.1	Gate	CV-1	CV-2
7.2	Globe	CV-4	CV-4, 5
7.3	Angle	-	CV-6
7.4	Check	-	-
8	NOTES		
8.1	Use Schedule 30 black steel on all sizes over 12".		
8.2	See Division 23, "Heating Ventilating and Air Conditioning" for special valves.		

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 4  
16 to 100 PSIG STEAM SUPPLY

1	Install pipe, valves and fittings as designated in this Schedule for this System.		
2	NOMINAL SIZE RANGE		
2.1	Minimum Diameter	3/4"	2 1/2"
2.2	Maximum Diameter	2"	20"
3	DESIGN		
3.1	Working Pressure PSIG	125	125
3.2	Working Temperature °F	350	350
4	PIPING DESIGNATIONS		
4.1	Sch. 40 Bl. St.	CP-2	CP-2
5	FITTING DESIGNATIONS		
5.1	250# Cast Iron Threaded	CF-2	-
5.2	125# Cast Iron Flanged	-	CF-4
5.3	Sch. 40 Wrt. St.	-	CF-5
6	JOINT DESIGNATIONS		
6.1	Threaded	CJ-1	-
6.2	Butt Welded	-	CJ-5
6.3	150# Flanged	-	CJ-43
7	VALVE DESIGNATIONS		
7.1	Gate	CV-1	CV-2
7.2	Globe	CV-4	CV-4, 5
7.3	Angle	-	CV-6
7.4	Check	-	-
8	NOTES		
8.1	Use Schedule 30 black steel on all sizes over 12".		
8.2	See Division 23, "Heating Ventilating and Air Conditioning" for special valves.		

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 5  
101 to 150 PSIG STEAM SUPPLY

1	Install pipe, valves and fittings as designated in this Schedule for this System.		
2	NOMINAL SIZE RANGE		
2.1	Minimum Diameter	3/4"	2 1/2"
2.2	Maximum Diameter	2"	20"
3	DESIGN		
3.1	Working Pressure PSIG	150	150
3.2	Working Temperature °F	350	350
4	PIPING DESIGNATIONS		
4.1	Sch. 40 Bl. St.	CP-2	CP-2
5	FITTING DESIGNATIONS		
5.1	250# Cast Iron Screwed	CF-2	-
5.2	250# Cast Iron Flanged	-	CF-43
5.3	Sch. 40 Wrt. St.	-	CF-5
6	JOINT DESIGNATIONS		
6.1	Threaded	CJ-1	-
6.2	Butt Welded	-	CJ-5
6.3	300# Flanged	-	CJ-43
7	VALVE DESIGNATIONS		
7.1	Gate	CV-1.4	CV-3.1
7.2	Globe	CV-4.1	CV-4.1, 5.1
7.3	Ball	-	CV-21.3
7.4	Angle	-	-
8	NOTES		
8.1	Use Schedule 40 unless otherwise noted.		
8.2	See Division 23, "Heating Ventilating and Air Conditioning" for special valves.		
8.3	Use Schedule 80 black steel pipe on 2" and smaller piping.		

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 8  
STEAM CONDENSATE, BLOWOFF AND RELIEF

1	Install pipe, valves and fittings as designated in this Schedule for this System.		
2	NOMINAL SIZE RANGE		
2.1	Minimum Diameter	3/4"	2 1/2"
2.2	Maximum Diameter	2"	12"
3	DESIGN		
3.1	Working Pressure PSIG	125	125
3.2	Working Temperature °F	250	250
4	PIPING DESIGNATIONS		
4.1	Sch. 80 Bl. St.	CP-2	CP-2
5	FITTING DESIGNATIONS		
5.1	125# Cast Iron	CF-2	-
5.2	Sch. 80 Wrt. St.	-	CF-5
6	JOINT DESIGNATIONS		
6.1	Threaded	CJ-1	-
6.2	Butt Weld	-	CJ-5
6.3	150# Flanged	-	CJ-43
7	VALVE DESIGNATIONS		
7.1	Gate	CV-1	CV-2
7.2	Globe	CV-4	CV-4, 5
7.3	Angle	-	CV-6
7.4	Blowoff	CV-26	CV-27
7.5	Swing Check	CV-7	CV-8
8	NOTES		
8.1	See Division 23 "Heating Ventilating and Air Conditioning" for special valves.		

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 9  
HIGH PRESSURE STEAM CONDENSATE,  
BLOWOFF AND RELIEF

- 1 Install pipe, valves and fittings as designated in this Schedule for this System.
- 2 NOMINAL SIZE RANGE
  - 2.1 Minimum Diameter 3/4"
  - 2.2 Maximum Diameter 2"
- 3 DESIGN
  - 3.1 Working Pressure PSIG 125
  - 3.2 Working Temperature °F 250
- 4 PIPING DESIGNATIONS
  - 4.1 Sch. 80 Bl. St. CP-2
- 5 FITTING DESIGNATIONS
  - 5.1 125# Cast Iron CF-2
- 6 JOINT DESIGNATIONS
  - 6.1 Threaded CJ-1
  - 6.2 Butt Weld -
  - 6.3 150# Flanged -
- 7 VALVE DESIGNATIONS
  - 7.1 Gate CV-1.4
  - 7.2 Swing Check CV-7
- 8 NOTES
  - 8.1 See Division 23 "Heating Ventilating and Air Conditioning" for special valves.
  - 8.2 See Division 23 "Conduit Encased Pipe" for buried condensate pipe system.

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 13  
COIL CONDENSATE

- 1 Install pipe, valves and fittings as designated in this Schedule for this System.
- 2 NOMINAL SIZE RANGE
  - 2.1 Minimum Diameter 1"
  - 2.2 Maximum Diameter 4"
- 3 DESIGN
  - 3.1 Working Pressure Ft. Hd. 10
  - 3.2 Working Temperature °F Ambient
- 4 PIPING DESIGNATIONS
  - 4.1 Hard "L" Copper CP-8
  - 4.2 Sch. 40 PVC CP-30
- 5 FITTING DESIGNATIONS
  - 5.1 Wrought CF-8
  - 5.2 Sch. 40 PVC CF-30
- 6 JOINT DESIGNATIONS
  - 6.1 Solder CJ-8
  - 6.2 Solvent Cement CJ-33
- 7 NOTES
  - 7.1 PVC in return air plenums shall be insulated. Reference Insulation Section 200180.
  - 7.2 All coil condensate piping shall be installed with slope of not less than 1/8" per foot.

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 14  
SANITARY, VENT AND STORM GRAVITY-INSIDE BUILDING

- 1 Install pipe, valves and fittings as designated in this Schedule for this System.
- 2 ABOVE GRADE
  - 2.1 SANITARY & STORM PIPE DESIGNATIONS

			FITTING DESIGNATIONS		JOINT DESIGNATIONS	
2.1.1	1 1/2" and Larger					
2.1.1.1	Cast Iron No Hub	CP-41	No Hub	CF-41	Coupling	CJ-41
2.1.1.2	DWV Copper	CP-7	Copper	CF-11	Solder	CJ-8
2.1.1.3	Sch. 40 DWV PVC	CP-33	PVC	CF-33	Solvent	CJ-33
  - 2.2 VENT PIPE DESIGNATIONS

2.2.1	1 1/2" and Larger					
2.2.1.1	Cast Iron No Hub	CP-41	No Hub	CF-41	Coupling	CJ-41
2.2.1.2	DWV Copper	CP-7	Copper	CF-11	Solder	CJ-8
2.2.1.3	Sch. 40 DWV PVC	CP-33	PVC	CF-33	Solvent	CJ-33
- 3 BELOW FLOOR
  - 3.1 SANITARY, STORM AND VENT

3.1.1	2" and Larger					
3.1.1.1	Cast Iron Hub	CP-40	Hub	CF-40	Gasket	CJ-40
3.1.1.2	Sch. 40 DWV PVC	CP-33	PVC	CF-33	Solvent	CJ-33
- 4 NOTES
  - 4.1 PVC in return air plenums shall be insulated. Reference Insulation Section 200180.

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 15  
SANITARY, VENT AND STORM  
GRAVITY-OUTSIDE BUILDING

1 Install pipe, valves and fittings as designated in this Schedule for this System.

2	SANITARY & STORM PIPE DESIGNATIONS		FITTING DESIGNATIONS		JOINT DESIGNATIONS	
2.1	2" and 3"					
2.1.1	Sch. 40 DWV PVC	CP-33	PVC	CF-33	Solvent	CJ-33
2.1.2	Sch. 40 ABS	CP-34	ABS	CF-34	Solvent	CJ-33
2.2	4" to 15"					
2.2.1	PVC SDR 35	CP-32	PVC	CF-32	Gasket	CJ-32
3	NOTES					
3.1	Use concrete pipe below roads and driveways.					

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 16  
SANITARY AND STORM, FORCED MAIN

1	Install pipe, valves and fittings as designated in this Schedule for this System.					
2	SANITARY & STORM PIPE DESIGNATIONS		FITTING DESIGNATIONS		JOINT DESIGNATIONS	
2.1	ABOVE GRADE					
2.1.1	2" to 4"					
2.1.1.1	Type L Copper	CP-8	Wrought Copper	CF-10	Solder	CJ-8
2.1.1.2	Sch. 40 Galv. St.	CP-2	Ductile Iron	CF-6	Grooved Mech.	CJ-6
3	BELOW FLOOR – INSIDE BUILDING					
3.1	2" to 4"					
3.1.1	Ductile Iron	CP-20	Ductile Iron	CF-20	Mech. Joint	CJ-20
4	BELOW GRADE – OUTSIDE BUILDING					
4.1	2" to 4"					
4.1.1	Ductile Iron	CP-20	Ductile Iron	CF-20	Mech. Joint	CJ-20

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 17  
DOMESTIC HOT & COLD WATER  
ABOVE GROUND

1	Install pipe, valves and fittings as designated in this Schedule for this System.		
2	NOMINAL SIZE RANGE		
2.1	Minimum Diameter	1/2"	4"
2.2	Maximum Diameter	3"	8"
3	DESIGN		
3.1	Working Pressure PSIG	125	125
3.2	Working Temperature °F	250	250
4	PIPING DESIGNATIONS		
4.1	Hard "L" Copper	CP-8	CP-8
5	FITTING DESIGNATIONS		
5.1	Cold Press	CF-8A	CF-8A
5.2	Wrought	CF-8	-
5.3	Grooved Mech.	-	CF-6
6	JOINT DESIGNATIONS		
6.1	Cold Press	CJ-8A	CJ-8A
6.2	Solder	CJ-8	-
6.3	Grooved	-	CJ-6
7	VALVES		
7.1	Ball	CV-20	Use only if specifically told to do so – CV-21
7.2	Angle	-	CV-6
7.3	Globe	CV-4, 5	CV-5
7.4	Check Horizontal Swing	CV-7, 8	CV-8
7.5	Butterfly	-	CV-23, 24
8	NOTES		
8.1	Install ball valves for balancing services.		
8.2	Use flange joint on 3" and larger pipe when connection to equipment or valves.		
8.3	See Division 22 "Plumbing" for special valves.		

PART 3 - EXECUTION (Continued)

SYSTEM PIPING SCHEDULE 19  
FIRE PROTECTION

1	Install pipe, valves and fittings as designated in this Schedule for this System			
2	LOCATION LIMITES	BELOW GROUND	ABOVE GROUND	
3	NOMINAL SIZE RANGE			
3.1	Minimum Diameter	4"	1"	2 1/2"
3.2	Maximum Diameter	12"	2"	8"
4	DESIGN			
4.1	Working Pressure PSIG	175	175	175
4.2	Working Temperature °F	WOG	WOG	WOG
5	PIPING DESIGNATIONS			
5.1	Ductile Iron	CP-20	-	-
5.2	Sch. 40 Bl. St.	-	CP-2	-
5.3	Sch. 10 Bl. St.	-	-	CP-2
6	FITTING DESIGNATIONS			
6.1	Ductile Iron Mech. Joint	CF-20	-	-
6.2	Class 125 Cast Iron	-	CF-2	-
6.3	Class 150 Malleable Iron	-	CF-1	-
6.4	Steel Grooved	-	-	CF-6
7	JOINT DESIGNATIONS			
7.1	Mechanical Joint	CJ-20	-	-
7.2	Threaded	-	CJ-1	-
7.3	Mech. Grooved	-	-	CJ-6
8	NOTES			
8.1	Valves are specified in Fire Protection Section 21 10 00.			
8.2	Provide manufacturer's standard gasket for service intended on mechanical joint pipe.			
8.3	Provide thrust blocks, tie-rods on fittings below grade as required by NFPA #24, Chapter 8.			
8.4	The minimum burial depth of exterior fire protection systems shall be 5'-0".			

### 3.02 PIPE SUPPORT

#### A. PIPE SUPPORT

1. Furnish and install supports, guides, anchors and swaybraces required for proper installation and support of pipe lines except supports noted to be furnished by others.
2. Pipe suspension shall prevent excessive stress and excessive variation in supporting force. Fabrication and installation of supports for pipe lines shall not constrain piping to cause excess transfer of load from supports to piping or from support to support when expansion or contraction occurs. Supports shall be capable of taking entire piping load imposed by expansion or contraction.
3. Where pipe vibration transmits objectionable vibration to building structure or attached equipment, hangers shall be supplemented by spring cushions or an energy absorbing means in the supports themselves, or through the addition of flexible piping connectors or other auxiliary equipment.
4. Piping system where flexibility is not desired shall be supported by rigid hangers.
5. See Section 20 00 10, "Attaching to Building Construction" for attaching pipe support to structure.

#### B. Vertical Pipe Risers

1. Support vertical runs under 15' long with hanger adjacent to elbows.
2. Support vertical runs over 15' with steel riser clamps. Weld clamps to pipe and support on building structure. Space clamps at every floor with maximum spacing of 28'.

#### C. Hanger Rods

1. Support horizontal pipe with hot rolled steel rod manufactured in accordance with ASTM A107. Space hanger rods to eliminate pipe sagging. Space hangers as listed below. Place hangers within 12" of each horizontal elbow.
2. Steel and Copper Hanger Spacing

<u>PIPE SIZE (NPS)</u>	<u>ROD SIZE (DIAMETER)</u>	<u>MAXIMUM HANGER SPACING</u>
1/2" thru 1-1/4"	3/8"	6'0"
1-1/2" and 3"	1/2"	10'0"
4" and 5"	5/8"	10'0"
6"	3/4"	10'0"
8" thru 12"	7/8"	15'0"
14" thru 18"	Two 7/8"	15'0"
20" thru 24"	Two 1"	15'0"

#### 3. PVC Pipe Support Spacing

<u>PIPE SIZE (NPS)</u>	<u>ROD SIZE (DIAMETER)</u>	<u>MAXIMUM HANGER SPACING</u>
1/2" thru 1"	3/8"	3'0"
1-1/4" thru 3"	3/8"	4'0"
4" thru 5"	1/2"	4'0"

6"

1/2"

4'0"

4. Piping with caulked joints to be supported at each joint.

D. Pipe Hangers (Pipe Suspended from Above)

1. For Hot Lines or Combination Hot and Cold Lines

- a. 2" and smaller iron or steel pipe: adjustable steel clevis hangers. Elcen 12; Grinnell 260; Fee & Mason 239; Crawford 11.
- b. 2" and smaller copper pipe: adjustable copper pipe ring. Elcen 394; Grinnell 97CP; Fee & Mason 365; Crawford.
- c. 2-1/2" thru 12" iron, steel and copper pipe: adjustable steel clevis hangers. Elcen 12; Grinnell 260; Fee & Mason 239; Crawford 11.
- d. 2-1/2" thru 12" iron, steel and copper pipe: adjustable swivel pipe roll (one hanger rod). Elcen 14; Grinnell 174; Fee & Mason 272; Crawford 129.
- e. 14" thru 24" o.d. iron or steel pipe: single pipe roll with adjustable sockets (two hanger rods). Elcen 15; Grinnell 171; Fee & Mason 170; Crawford 15.

2. For Cold Lines

- a. All sizes iron or steel pipe: Elcen 12; Grinnell 260; Fee & Mason 239; Crawford 11.
- b. All sizes copper pipe: adjustable copper-plated ring. Elcen 394; Grinnell 97CP; Fee & Mason 365; Crawford.

3. All hangers used on lines requiring insulation and vapor barrier shall have hangers oversized to allow insulation to pass thru hanger. Install insulation cradles or wood blocks the same thickness as insulation so insulation will not be crushed. Insulation cradles or wood blocks shall be designed for this specific use.

E. Pipe Carriers (Pipe Supported from Below on Racks, Piers, Stands or Trapeze Support)

1. For Hot Lines or Combination Hot and Cold Lines

- a. 3" and smaller Pipe: roller chair with steel U bar support. Elcen 16; Grinnell 176; Fee & Mason 168; Crawford 130.
- b. 4" and larger Pipe: adjustable pipe roll stand with base plate. Elcen 20; Grinnell 274; Fee & Mason 161; Crawford 19.

2. For Cold Lines: all pipe sizes supported on steel pipe chair designed to contain pipe movement in direction perpendicular to pipe run but allow some movement in direction of pipe run.

3. All hangers used on lines requiring insulation and vapor barrier shall have hangers oversized to allow insulation to pass thru hanger. Install insulation cradles or wood blocks the same thickness as insulation so insulation will not be crushed. Insulation cradles or wood blocks shall be designed for this specific use.

F. For sprinkler piping support refer to NFPA#13 (3-10 hangers).

G. Supports for sprinkler piping to be in conformance with NFPA 13, if modified by this section.

- H. For piping hanger rod attachment to building, see Section 20 00 10 "Attaching to Building Construction."

### 3.03 UNDERGROUND PIPING

- A. See Excavation and Backfilling Section 20 00 50.

### 3.04 ESCUTCHEONS

- A. See Escutcheons, Section 20 00 50.

### 3.05 INSTALLATION OF VALVES

- A. Locate valves accessibly and arrange to permit easy removal of fixtures and equipment they serve.
- B. Unless otherwise noted, all valves shall be full size of lines in which they are placed.
- C. Install all piping and shut-off valves full pipe size as shown on Drawings. Reduce at control valves to control valve size.
- D. Valves mounted in horizontal lines shall not have their stems and bonnets pointed below horizontal position unless indicated on Drawings.
- E. Provide valves with 3/4" garden hose adaptor for draining low points, boilers, chillers, coils, etc. with cap and chain. Use ball valves for systems which operate below 120°F. Use gate (Crane 431) or globe valves for systems which operate above 121°F.
- F. Mount all globe valves to close against flow pressure. Flow should be against bottom of plug.
- G. Remove bonnets and trim from all valves before soldering, brazing or welding in piping system. Protect seating surfaces during installation. Clean valve parts thoroughly before reassembling. Install bonnet with valve in open position. Follow manufacturers written instructions to protect valves from overheating during installation.
- H. Install all valves with discs or plugs in open position. Close only when assured that sealing parts are free from foreign material. Weld scale or similar foreign materials found embedded in sealing surfaces will require installation of new trim or complete valve.
- I. If grooved piping system is used, then only grooved end valves shall be used. **If grooved piping is used, it is not acceptable to use grooved to flanged adapters to install flanged valves.**
- J. Install valves as required by control contractor.

### 3.06 INSTALLATION OF PIPING

- A. Offset piping to avoid interference with other work to increase head room under piping.

- B. Contractor may, at his option, use pipe bending equipment to form full lengths of pipe to proper configuration indicated on Drawings.
- C. Remove raised face from flanges that are to match cast iron flat face patterns.
- D. Coat studs, nuts, flange faces and metallic gaskets with material similar to molybdenum disulphide before assembly.
- E. Pipe sizes refer to nominal inside pipe diameter except on copper refrigeration lines and steel and wrought iron pipe 14" and larger.
- F. Bonney Weldolet Forge Branch Outlet Fittings may be used where steel with welding fittings are specified in lieu of branch outlet tees, provided branch tee is 2 sizes smaller than main. Nipples welded into mains not acceptable.
- G. Use galvanized fittings and unions with galvanized pipe.
- H. Caulk clearance space in floor sleeves with plastic compound or fire stop material as required.
- I. Caulk exterior wall sleeves with thiokol.
- J. Install chromeplated pipe escutcheons on bare exposed pipe at wall, floor and ceiling penetrations. Reference 20 00 50 Escutcheons.
- K. Use dielectric couplings when joining dissimilar piping materials.
- L. Piping shall not pass over electrical apparatus. If conflict is shown on Drawings, notify Engineer prior to installing pipe.
- M. Refer to General Requirements for installation of sleeves, escutcheons, cutting and fitting and attaching to building construction.
- N. Refer to Insulation Section 20 01 80 for insulation data. PVC in return air plenums shall be insulated
- O. Conceal all pipes where provisions have been made for this purpose.
- P. In case of conflict on Drawings as to pipe size, the larger pipe size shall be installed.
- Q. Joints shall be approved type, gas and watertight for system pressure.
- R. All pipes shall be cut square, reamed, chamfered and free of all burrs and obstructions. Pipe ends shall have full-bore openings and not be undercut.
- S. Piping not serving elevator equipment rooms shall not pass through elevator equipment rooms. If conflict is shown on drawings, notify Engineer prior to installing pipe.
- T. Install wells, thread-o-lets and T's as required by control contractor.
- U. Copper pipe shall not come in direct contact with mortar or grout. Where copper pipes are exposed to mortar or grout, pipes shall be wrapped with duct tape. This typically happens when pipes pass through masonry walls.

- V. All pipes to equipment and isolation valves shall be full pipe size as shown on Drawings regardless of equipment connection size. Use reducers at equipment to reduce to equipment size.
- W. Grooved product must be installed per manufacturer's written instructions, which may or may not include extreme lubricant, torque wrench and specified torque ratings. Manufacturer's representative must provide on-site training to field personnel on installation of product.
- X. No pulled "T" drilling of copper piping for branch takeoff's allowed.
- Y. Condensate piping shall be installed with slope of not less than 1/8" per foot.

### 3.07 PIPE CLEANING

- A. Swab to remove dirt or scale.
- B. Flush water system until water runs clear.
- C. Operate steam systems until condensate runs clear.
- D. Clean all strainers and traps.

### 3.08 TESTING PIPING

- A. Test all piping at 1 1/2 times operating pressure.
- B. Test all concealed work before covering with earth, insulation or furring.
- C. Notify Engineer not less than 24 hours in advance of all tests.
- D. Furnish all fuel and necessary equipment required for tests.
- E. Promptly repair all leaks and reapply tests.
- F. Install blind flanges or plugs in order to make tests.
- G. See Specification Divisions 22 and 23 for additional pressure testing requirements.

### 3.09 STERILIZATION OF DOMESTIC WATER SYSTEM

- A. Flush system thoroughly until water runs clear.
- B. Entire system shall be filled with a water/chlorine solution containing 50 parts per million of chlorine. The system or part thereof shall be valved off and allowed to stand for 24 hours; or the system or part thereof shall be filled with a water/chlorine solution containing at least 200 parts per million of chlorine and allowed to stand for three hours.
- C. Following the allowed standing time, the system shall be flushed with clean potable water until chlorine does not remain in the water coming from the system.

- D. After the above requirements are satisfied, submit samples to local Board of Health for approval.
- E. Sterilization shall be redone until approval from the State Board of Health is obtained.

### 3.010 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook", using lead-free solder alloy complying with ASTM C 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook", "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
  - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
  - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
  - 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
  - 4. PVC Non-pressure Piping: Join according to ASTM D 2855.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

- L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
  - 1. Plain-End Pipe and Fittings: Use butt fusion.
  - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
- M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

### 3.011 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
  - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
  - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
  - 5. "Pulled Tee's" in copper piping are not allowed.

### 3.012 GROOVED PIPING

- A. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor's representative is not considered qualified to conduct the training.

For applicable projects, the grooved coupling manufacturer shall provide inspection services and/or certify the installing contractor for the installation of their product. The manufacturer's factory trained representative shall provide certification training for the installing contractor's field personnel in the use of grooving tools, application of groove, and product installation. The training program shall be designed, developed, administered and evaluated in accordance to the ANSI/IACET Standard for Continuing Education and Training. (IACET-International Association for Continuing Education and Training)

END OF SECTION 200060

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## SECTION 200180 – COMMON INSULATION FOR PLUMBING & HVAC

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Sections, apply to this Section.

#### 1.02 SUMMARY

- A. This section includes field applied insulation and jacket materials for all systems. These systems include:
  - 1. System Insulation Schedule 1:
    - Heating Water Pipe
    - Low and High Pressure Steam Pipe
    - Steam Condensate Pipe
  - 2. System Insulation Schedule 2:
    - Chilled Water Pipe
  - 3. System Insulation Schedule 3:
    - Coil Condensate Pipe
    - Domestic Cold Water Pipe
    - Domestic Hot Water Pipe
    - Sanitary Waste Pipe
  - 4. System Insulation Schedule 5:
    - Shell and Tube Heat Exchanger
  - 5. System Insulation Schedule 7:
    - Storm Water Pipe
  - 6. System Insulation Schedule 8:
    - Chilled Water Pumps
    - Roof Drain Basins
  - 7. System Insulation Schedule 9:
    - Heating and Air Conditioning: Supply Air Ductwork
  - 8. System Insulation Schedule 9A:
    - Air Handling Unit: Outside Air Intake Ductwork
  - 9. System Insulation Schedule 10:
    - Heating and Air Conditioning: Return Air Ductwork
- B. Any equipment that is to be factory insulated is specified with respective equipment.

- C. All PVC piping installed in a ceiling plenum shall be insulated to provide a flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
- D. Any piece of equipment, pipe, or duct, installed in this contract, which is typically insulated to prevent condensation, shall be insulated unless specifically noted otherwise.
- E. Internally lined sheet metal is specified in Metal Ducts, Section 23 31 13.
- F. Related sections include all applicable Mechanical Sections.

#### 1.03 SUBMITTALS

- A. Submit product data for insulation, jacket materials and fittings used in each system as required in Section 20 00 10, "Shop Drawings".
- B. Product data shall include thermal conductivity, thickness, jacket material, insulation material, sealing compounds, flame-spread and smoke-developed ratings for each type of product to be used.
- C. Submit test reports of independent testing agency showing conformance with flame-spread and smoke-developed ratings.

#### 1.04 QUALITY ASSURANCE

- A. Insulation Contractor shall have completed a minimum of two (2) projects of similar scope. Upon request, the Insulation Contractor shall provide a list of similar projects and references to the Engineer. The engineer may wish to inspect work previously installed by the Insulation Contractor.
- B. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
- C. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. All insulation to be shipped to site in unopened containers as packaged by Insulation Manufacturers.
- B. All containers shall state contents within.
- C. Store in clean dry area properly protected from weather and physical damage.
- D. Open only containers required to be opened as construction progresses.

#### 1.06 COORDINATION

- A. Coordinate size and location of supports, hangers and insulation shields.

- B. Coordinate hanger sizes and piping penetrations for pipes requiring insulation, wood blocking and saddles with piping installer.

## 1.07 SCHEDULING

- A. Schedule insulation application after pipe testing and heat trace has been installed.

## PART 2 - PRODUCTS

### 2.01 INSULATION MATERIALS

- A. Refer to Insulation Material Schedules in Execution portion of this Section for Insulation types to be used for each system. When more than one is shown, contractor may choose which type is to be installed.

- B. FIBERGLASS INSULATION

1. Glass fiber bonded with a thermosetting resin with thermal conductivity of .25 or less @ 75°F. 3-pound per cubic foot density. Designed for use to 850°F.
  - a. Preformed Pipe Insulation with Jacket: ASTM C547, Type 1, Class 1 with factory applied all-purpose, vapor-retarder jacket, 0.02 perm max water vapor permeance.
  - b. Board Insulation: with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil and vinyl film.
  - c. Blanket Insulation: ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
  - a. Class 1, Grade A for bonding glass cloth and tape to un-faced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to un-faced glass-fiber insulation.
  - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
5. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
6. Mineral-Fiber, hydraulic-setting insulating and finishing cement: Comply with ASTM C 449/C 449M.
7. Manufacturers:
  - a. CertainTeed Manson
  - b. Knauf Insulation.
  - c. Owens-Corning Fiberglas Corp.
  - d. Schuller International, Inc.
  - e. Johns Manville

- C. FOAMGLASS INSULATION

1. Inorganic cellular glass insulating material with hermetically sealed cells, non-absorptive and noncombustible. Designed for use from 35°F to 350°F.
  - a. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class I.
  - b. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.
  - c. Block Insulation: ASTM C 552, Type I.
  - d. Special-Shaped Insulation: ASTM C 552, Type III.
  - e. Board Insulation: ASTM C 552, Type IV.
2. Manufacturers:
  - a. Pittsburgh - Corning Corporation

D. FLEXIBLE ELASTOMERIC INSULATION

1. Closed cellular or expanded rubber material of high insulating efficiency (K of .25 or better @ 75°F) and designed for use with temperatures from -40° to 210°F. Odorless, self-extinguishing and vapor resistant in compliance with ASTM E-84, 25/50 flame smoke rating. Approved for use in return air plenums.
  - a. Preformed pipe insulation: ASTM C 534, Type I.
  - b. Sheet insulation: ASTM C 534, Type II.
2. Adhesive: As recommended by Insulation Material Manufacturer.
3. Ultraviolet – Protective Coating: As recommended by Insulation Manufacturer.
4. Manufacturers:
  - a. Armacell AP
  - b. K-Flex
  - c. Aeroflex

E. CALCIUM SILICATE

1. Rigid hydrous calcium silicate heat insulating block with thermal conductivity of .4 or less @ 300°F. 15 pounds per cubic foot density. Designed for use to 1200°F. ASTM E 84 - 0 Flame Spread; 0 Smoke Developed.
  - a. Preformed Pipe and Block Insulation: ASTM C 533, Type I.
2. Insulating Cements: ASTM C 195.
3. Manufacturers:
  - a. Owens-Corning Fiberglas Corp.
  - b. Pabco
  - c. Schuller International, Inc.

F. DUCT LINER: See Section 23 31 13.

G. FLEXIBLE EPDM RUBBER SHEET

1. Flexible closed cell, lightweight elastomeric EPDM material with Ultraviolet resistance and insulating qualities for use outdoors.

2. Technical Data

Property	Test Method	Result
Thickness	-	1 ½".
Thermal Conductivity	ASTM C177/C518	0.245 k-value
Service Temperature	ASTM C 411	-297 F to +300 F
Surface Burning Characteristics	ASTM D 635 ASTM E 84	Self-Extinguishing Flame 25, Smoke 50
Water Absorption	ASTM C 209	0.2% max
Vapor Permeance	ASTM E 96	.03 perms
UV Resistance	ASTM G 7/G90	Excellent
Ozone Resistance	ASTM D 1171	No Cracking
Water Vapor Sorption	ASTM C 1104	0.00 %
Fungi Resistance	ASTM C 1338/ G21 /UL181	No Growth
Dimensional Stability	ASTM C 356	7 % max

3. Manufacturers:

- a. Aeroflex USA, Inc. – Aerocel.

2.02 ADHESIVES

- A. Adhesives or mastics used in the application or manufacture of insulating materials shall be fire retardant with UL flame rating not exceeding 25 and smoke developed rating not exceeding 50 (on dry film) when tested in accordance with ASTM E 84. All adhesives specifically designed for respective application as noted by insulation manufacturer.

2.03 JACKETS

A. PVC Jacket

1. High-impact

- a. Fittings – Gloss White, preformed, 30 Mill, PVC jacket designed for use with and provided by same manufacturer of insulation. Fiberglass insert wrapped around fitting and covered by PVC preformed jacket piping insulation system.
- b. Sheet – Gloss White, preformed, pre-cut and curled 20 mil PVC jacket designed for use with and provided by same manufacturer of piping insulation system. Ultraviolet-resistant suitable for outdoor service and temperature range 0 – 150°F. Jacket to be completely sealed with solvent weld for vapor proof barrier where noted in schedule.

B. Foil and Paper Jacket

1. Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil. Maximum of .02 perms moisture vapor transmission, ASTM C 921, Type I, Max 25/50 flame smoke rating.

2.04 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape

1. Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, pre-sized a minimum of 8 oz./sq. yd. (270 g/sq. m). Tape Width: 4 inches (100 mm).

B. Bands

1. 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:
  - a. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.
  - b. Aluminum: 0.007 inch (0.18 mm) thick.

C. Wire

1. 0.080-inch (2.0 mm), nickel-copper alloy; 0.062-inch (1.6 mm), soft-annealed, stainless steel; or 0.062-inch (1.6 mm), soft-annealed, galvanized steel.

D. Welded-Attached Anchor Pins and Washers

1. Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
  - a. Welded Pin Holding Capacity: 100 lb (45 kg) for direct pull perpendicular to the attached surface.

E. Adhesive-Attached Anchor Pins and Speed Washers

1. Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
  - a. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperature of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb (45 kg) for direct pull perpendicular to the adhered surface.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install Insulation for each system as designated in the Insulation Material Schedules on the following pages.
- B. When more than one type of insulation system is specified, contractor may choose which type is installed.
- C. Reference Products, Part 2 of this Section for specifications and manufacturers of insulation materials designated to be installed in Insulation Material Schedules.

### 3.0 EXECUTION (Continued)

### SYSTEM INSULATION SCHEDULE 1: HEATING WATER PIPE LOW AND HIGH PRESSURE STEAM PIPE STEAM CONDENSATE PIPE

1 Install insulation materials as designated in this schedule for system(s) listed.

2	LOCATION	INSIDE			OUTSIDE		
3	INSULATION						
3.1	Pipe	Fiberglass-Preformed with Jacket			Fiberglass-Preformed with Jacket		
3.2	Fitting	Fiberglass Blanket			Fiberglass Blanket		
4	INSULATION THICKNESS						
4.1	Pipe Size	≤2"	2 ½ ", 3"	≥4"	≤2"	2 ½ ", 3"	≥4"
4.2	Insulation Thickness	1 ½ "	1 ½ "	2 ½ "	1 ½ "	1 ½ "	2 ½ "
5	JACKETS						
5.1	Pipe	Integral to Insulation			Stainless Steel		
5.2	Fittings	Preformed PVC (See Note 6.3)			Preformed Stainless Steel		
5.3	Vapor-Retardant	No					

### 6 NOTES

- 6.1 On VAV Boxes with heating coils, wrap ends of coils, exposed to space adjacent to coils with blanket type insulation. Secure with tape for vapor retarder surface.
- 6.2 Where pipe insulation is to be painted, install glass cloth jacket. Prior to finish paint, paint with one coat of fire retardant, washable, white liquid plastic coating. Confirm compatibility with finish paint prior to painting.
- 6.3 Steam Valves, PRV's and similar devices which require service shall have removable, reusable insulation covers, fabricated with core insulation that are manufactured from fabrics, suitable for high steam temperatures, fiberglass blanket rated to 1000°F, securement systems consisting of Velcro flap at parting seam, circumferential belts, and rope draw cords at terminal ends. Removable covers as manufactured by Megawrap, Evansville IN, or equal.

### 3.0 EXECUTION (Continued)

### SYSTEM INSULATION SCHEDULE 2: CHILLED WATER PIPE

1 Install insulation materials as designated in this schedule for system listed.

2	LOCATION	INSIDE	OUTSIDE
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3 INSULATION

3.1	Pipe	Fiberglass-Preformed with Jacket	Fiberglass- Preformed with Jacket
-----	------	-------------------------------------	---

3.2	Fitting	Fiberglass Blanket	Preformed Fitting
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4 INSULATION THICKNESS

4.1	Pipe Size	All
-----	-----------	-----

4.2	Thickness	1"
-----	-----------	----

5 JACKETS

5.1	Pipe	Integral to Insulation	Aluminum Jacket
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5.2	Fittings	Preformed PVC	Stainless Steel Jack- et
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5.3	Vapor-Retardant	Yes
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6 NOTES

6.1 All chilled water pump bodies, air separators and miscellaneous chilled water equipment to be insulated in their entirety with 1" flexible elastomeric.

6.2 Where pipe insulation is to be painted, install glass cloth jacket. Prior to finish paint, paint with one coat of fire retardant, washable, white liquid plastic coating. Confirm compatibility with finish paint prior to painting.

SYSTEM INSULATION SCHEDULE 3:  
COIL CONDENSATE PIPE  
DOMESTIC COLD WATER PIPE  
DOMESTIC HOT WATER PIPE  
SANITARY WASTE PIPE

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### SYSTEM INSULATION SCHEDULE 5: SHELL AND TUBE HEAT EXCHANGER

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3.0 EXECUTION (Continued)

SYSTEM INSULATION SCHEDULE 7:  
STORM WATER

- 1 Install insulation materials as designated in this schedule for system(s) listed.
- 2 SERVICE INSIDE - HORIZONTAL
- 3 INSULATION MATERIAL
  - 3.1 Pipe Preformed Fiberglass with Jacket
  - 3.2 Fitting Fiberglass Blanket
- 4 INSULATION THICKNESS
  - 4.1 Pipe Size All
  - 4.2 Thickness 1"
- 5 JACKETS
  - 5.1 Pipe Integral to Insulation
  - 5.2 Fittings Preformed PVC
  - 5.3 Vapor-Retardant Yes
- 6 NOTES
  - 6.1 Where pipe insulation is to be painted, install glass cloth jacket. Prior to finish paint, paint with one coat of fire retardant, washable, white liquid plastic coating. Confirm compatibility with finish paint prior to painting.

3.0 EXECUTION (Continued)

SYSTEM INSULATION SCHEDULE 8:  
CHILLED WATER PUMPS  
ROOF DRAIN BASINS

- 1 Install insulation materials as designated in this schedule for system(s) listed.
- 2 LOCATION INSIDE
- 3 INSULATION MATERIAL Elastomeric
- 4 INSULATION THICKNESS 3/4"
- 5 JACKETS
- 5.1 Pipe
- 5.2 Fittings
- 5.3 Vapor-Retardant Yes

### 3.0 EXECUTION (Continued)

### SYSTEM INSULATION SCHEDULE 9: HEATING AND AIR CONDITIONING: SUPPLY AIR DUCTWORK

1 Install insulation materials as designated in this schedule for system.

2	LOCATION	INSIDE	INSIDE	INSIDE	EXTERIOR
3	INSULATION MATERIAL	3/4 lb. Flexible Fiberglass	3 lb. Rigid Fiberglass	Flexible Elastomeric	Flexible EPDM Rub- ber
4	INSULATION THICKNESS	1 1/2"	1 1/2"	3/4"	2"
5	JACKETS	FSK	FSK	FSK	Multi Layer Weather- proof
5.1	Vapor-Retardant	Yes	Yes	Yes	Yes

#### 6 NOTES

- 6.1 Use rigid or flexible elastomeric insulation in mechanical rooms. All other areas may be flexible fiberglass.
- 6.2 Where ductwork is to be painted, install 3 lb. rigid insulation with glass cloth jacket. Paint with one coat of fire retardant washable white liquid plastic coating. Confirm compatibility with finish paint prior to painting.
- 6.3 Insulate relief air plenums, ductwork, etc., from relief damper to a point where duct or plenum enters unconditioned space.
- 6.4 Insulate ends of reheat coils including VAV box reheat coils in all applications where heating coils are in air conditioning supply ductwork. Install vapor barrier over insulation and seal water tight to adjacent insulation vapor barrier.
- 6.5 Externally insulate supply air slot diffuser plenums with flexible fiberglass.
- 6.6 External insulation to have a 1" crown on top to shed water.
- 6.7 **Where supply and return air branch ducts containing volume dampers are covered using duct wrap, expose volume damper actuator through duct wrap and "spot" paint the duct wrap around the actuator a bright and contrasting color for ease in visually locating the actuator while standing on the floor below the duct.**

3.0 EXECUTION (Continued)

SYSTEM INSULATION SCHEDULE 9A:  
SYSTEM INSULATION SCHEDULE 9A:  
AIR HANDLING UNIT:  
OUTSIDE AIR INTAKE DUCTWORK

- 1 Install insulation materials as designated in this schedule for system.
- 2 LOCATION INSIDE INSIDE
- 3 INSULATION MATERIAL 3 lb. Rigid  
Fiberglass
- 4 INSULATION THICKNESS 2"
- 5 JACKETS FSK
- 5.1 Vapor-Retardant Yes
- 6 NOTES
- 6.1 Insulate all outside air intake ductwork including but not limited to ductwork serving air handling units and boilers within building envelope. No need to insulate when installed on outside of insulation barrier.
- 6.2 Use rigid insulation in mechanical rooms. All other areas may be flexible fiberglass. Combustion air ductwork serving condensing boilers and water heaters to be insulated.
- 6.3 Where ductwork is to be painted, install 3 lb. rigid insulation with glass cloth jacket. Paint with one coat of fire retardant washable white liquid plastic coating. Confirm compatibility with finish paint prior to painting.

3.0 EXECUTION (Continued)

SYSTEM INSULATION SCHEDULE 10:  
HEATING AND AIR CONDITIONING:  
RETURN AIR DUCTWORK

1	Install insulation materials as designated in this schedule for this system.			
2	LOCATION	SEE NOTES	SEE NOTES	SEE NOTES
3	INSULATION MATERIAL	3/4 lb. Fiberglass	3 lb. Fiberglass	Flexible Elastomeric
4	INSULATION THICKNESS	1 1/2"	1 1/2"	1/2"
5	JACKETS	FSK	FSK	FSK
5.1	Vapor-Retardant	No	No	No
6	NOTES			
6.1	Insulate return air ductwork in unconditioned attics. For unconditioned machine rooms insulate with rigid fiberglass insulation.			

### 3.03 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.04 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 3.05 GENERAL APPLICATION REQUIREMENTS

- A. All insulation that is to be painted shall be covered with glass cloth jacket unless noted otherwise.
- B. Apply insulation only after pipes, ducts and equipment have been tested and cleaned.
- C. Protect furniture, equipment, ducts, pipes, etc. with tarpaulins. Keep premises clean.
- D. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the entire length.
- E. Refer to schedules at the beginning of this Section for insulation materials and thickness, jackets, and fittings required for each system. Unless otherwise indicated, insulation shall be the same type throughout the same service.
- F. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- G. Where insulation is applied on ducts, pipes and equipment which are against columns, walls or other equipment without adequate space for insulation, finish off insulation in workmanlike manner to meet approval of Engineer.
- H. Apply multiple layers of insulation with longitudinal and end seams staggered.
- I. Seal joints, seams and ends of insulation with vapor-retardant mastic on insulation with a compound recommended by the insulation material manufacturer on systems indicated to receive a vapor retardant.
- J. Keep insulation materials dry during application and finishing.
- K. Insulation shall be applied by craftsmen who are qualified to install insulation.
- L. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- M. Apply insulation with the least number of joints practical.

- N. Apply insulation over fittings and specialties, with continuous thermal and vapor-retardant integrity, on systems noted to have vapor-retardant jacket.
- O. Provide removable sections of insulation or insulation boxes at all points where access is required for servicing of equipment on systems not requiring vapor-retardant jacket.
- P. Exposed is defined to mean visible from working zones of finished building. Concealed signifies opposite. Pipes and ducts above ceilings and in crawl tunnels are considered to be concealed. Finished rooms are defined as office, workrooms, instruction, store room areas, equipment rooms, walking tunnels, etc.
- Q. Aluminum jackets shall be installed in high traffic areas subject to damage.
- R. On systems not requiring vapor-retardant, neatly bevel insulation at all flanges, access cover plates, etc. so that bolts may be removed without disturbing insulation.
- S. All hangers used on lines requiring insulation and vapor barrier shall have hangers oversized and insulation cradles to allow insulation to pass thru hanger.
- T. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- U. Whenever Insulation Jacket is noted as Vapor Retardant: Overlap insulation facing at seams a minimum of one inch and secure with pressure-sensitive tape or adhesive as recommended by Manufacturer.
- V. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
- W. Seal penetrations with vapor-retardant mastic.
- X. Apply insulation for exterior applications tightly joined to interior insulation ends.
- Y. Seal insulation to roof flashing with vapor-retardant mastic.
- Z. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions.
- AA. Insulation Terminations: For insulation application where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant.
- BB. Do not insulate over equipment name plate data.
- CC. Seal all punctures in vapor retardant jacket with vapor-barrier adhesive on cooling piping and air conditioning ducts.
- DD. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- EE. Do not weld brackets, clips, or other attachment devices to item being insulated unless specifically noted to do so.

### 3.06 DUCTWORK AND EQUIPMENT INSULATION

#### A. Blanket Insulation Application

1. Apply insulation with integral jackets as follows:
  - a. Pull jacket tight and smooth.
  - b. Install anchor pins and speed washers to keep insulation from sagging when duct width exceeds 22".
  - c. Joints and Seams: Cover with tape and vapor retardant as recommended by insulation material manufacturer to maintain vapor seal.
  - d. Vapor-Retardant Mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.
2. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire-rated wall and partition penetrations. Maintain vapor-retardant barrier.
3. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor. Provide vapor-retardant mastic on insulation indicated to receive vapor-retardant.

#### B. Board and Block Insulation Application

1. Blankets, Board, and Block Applications: Secure insulation with adhesive and anchor pins with speed washers.
  - a. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of surfaces to be insulated.
  - b. Groove and score insulation materials to fit as closely as possible to the surfaces, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.
  - c. Protect exposed corners with secured corner angles.
  - d. Install adhesive-attached or self-adhesive anchor pins and speed washers on sides and bottoms of surfaces to be insulated as follows:
    - 1) Do not weld anchor pins to ASME-labeled pressure vessels.
    - 2) 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
    - 3) Do not over-compress insulation during installation.
    - 4) Cut and miter insulation segments to fit curved sided and dome heads of tanks and vessels.
2. Impale insulation over anchor pins and attach speed washers.
3. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. Secure each layer of insulation with stainless-steel bands.
5. Stagger joints between insulation layers at least 3 inches (75 mm).
6. Apply insulation in removable segments on access doors and other elements that require removal for service.
7. Bevel and seal insulation ends around access panels, manholes, hand holes, ASME stamps, and nameplates.
8. Apply vapor-retardant mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retardant.

C. Flexible Elastomeric Thermal Insulation Applications:

1. Apply insulation over entire surface to be insulated according to the manufacturer's written instructions.
2. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
3. Seal longitudinal seams and end joints for Vapor Retardant installation.

3.07 FIELD-APPLIED JACKET APPLICATION

A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of jacket manufacturer's recommended adhesive.
3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

3.08 PIPING APPLICATION REQUIREMENTS

A. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches (100mm) o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). Apply insulation with longitudinal seams at bottom pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
  - a. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.
4. Vapor-Retardant Mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retardant mastic.

B. Apply insulation to fittings and elbows as follows:

1. Apply pre-molded insulation sections of the same material as straight segments of pipe insulation where scheduled. Secure according to manufacturer's written instructions.
2. Apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Apply jacket material overlapping seams at least 1 inch (25 mm) at each end. Secure with manufacturer's recommended adhesive, attachments and accessories. Seal seams with tape. Use vapor-retardant mastic on insulation indicated to receive vapor-retardant.

C. Apply insulation to valves and specialties as follows:

1. Apply pre-molded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When pre-molded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For strainers, arrange insulation for access to strainer basket without disturbing insulation.
  3. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape. Also, seal seams with vapor-retardant mastic on insulation indicated to receive vapor-retardant.
  4. On piping 3" and smaller, not requiring vapor-retardant, fittings may be insulated with insulating cement equal in thickness to adjoining pipe insulation and troweled to smooth even finish. Do not insulate heating water pipe valves or unions.
  5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.
- D. Floor Penetrations: Apply insulation continuously through floor assembly. Seal insulation with vapor-retardant mastic where floor supports penetrate vapor-retardant.
- E. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.
- F. Hangers and Anchors: All hangers used on lines requiring insulation shall have hangers oversized and insulation support shield to allow insulation to pass continuously thru hanger.
1. Install insert materials on all piping 1 1/2" and larger. Apply insulation to tightly joint the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
  2. Fabricate inserts of heavy density insulating material suitable for temperature. Insulation inserts shall not be less than the following lengths:

1 1/2" to 2 1/2" pipe size	10" long
3" to 6" pipe size	12" long
8" to 10" pipe size	16" long
12" and over	22" long
  3. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- G. Apply insulation to flanges as follows:
1. Apply preformed pipe insulation to outer diameter of pipe flange.
  2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
  3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
  4. Apply jacket material with manufacturer's recommended adhesive, overlapping seams at least 2 inch (50 mm), and seal joints with vapor-retardant mastic.

END OF SECTION 200180

## SECTION 211000 – WATER BASED FIRE SUPPRESSION

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following fire-suppression piping inside the building:
  - 1. Manual wet-type standpipe systems.
  - 2. Wet-pipe sprinkler systems.
- B. See Division 10 Sections "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
- C. See Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

#### 1.02 GENERAL

- A. Provide all material, labor, engineering and operations for the installation of complete and operable fire suppression system as shown on the Drawings and as specified herein.
- B. Provide all equipment and materials including pipes, valves, fittings, sprinkler heads, fire department connections, backflow preventer, pipe supports, specialties and accessories necessary for a complete and approved fire suppression system.
- C. This Contractor shall be completely responsible for the design, layout, submittals, installation, testing, certification and acceptance of the fire suppression system by the Indiana Department of Homeland Security Division for Fire and Building Safety.

#### 1.03 PERFORMANCE REQUIREMENTS

- A. Standard Piping System Component Working Pressure: Listed for at least 175 psig.
- B. Fire-suppression standpipe system design shall be approved by authorities having jurisdiction.
  - 1. Maximum Residual Pressure at Each Class II Hose-Connection Outlet: 100 psig.
- C. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.
  - 1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
  - 2. Sprinkler Occupancy Hazard Classifications:
    - a. Auditoriums: Ordinary Hazard, Group 1.
    - b. Building Service Areas: Ordinary Hazard, Group 1.
    - c. Classrooms: Light Hazard.
    - d. Corridors: Light Hazard.
    - e. Display Cases: Light Hazard.
    - f. Electrical Equipment Rooms: Ordinary Hazard, Group 1.

- g. General Storage Areas: Ordinary Hazard, Group 1.
    - h. Janitors: Ordinary Hazard, Group 1.
    - i. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
    - j. Office and Public Areas: Light Hazard.
    - k. Restrooms: Light Hazard.
    - l. Stages: Ordinary Hazard, Group 2.
    - m. Stagecraft: Ordinary Hazard, Group 2.
    - n. Stairs: Light Hazard.
  - 3. Minimum Density for Automatic-Sprinkler Piping Design:
    - a. Light-Hazard Occupancy: 0.10 gpm/sq. ft. over 1500 sq. ft.
    - b. Ordinary-Hazard, Group 1 Occupancy: 0.20 gpm/sq. ft. over 2500 sq. ft.
    - c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm/sq. ft. over 2500 sq. ft. (stage calculation should be over entire area of stage, up to max of 2500 sq. ft.).
    - d. Remote area may NOT be reduced where listed quick response sprinklers are used.
  - 4. Maximum Protection Area per Sprinkler:
    - a. Light Hazard: 225 sq. ft.
    - b. Ordinary Hazard: 130 sq. ft.
    - c. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.
    - d. When using extended coverage sprinkler heads, maximum protection area per sprinkler may be increased up to 400 sq. ft. in unobstructed light hazard and ordinary hazard locations and as allowable based on hydraulic calculations.
  - 5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13, unless otherwise indicated:
    - a. 250 gpm for 60 to 90 minutes.
  - D. Seismic Performance: Fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13 and ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."
- 1.04 SUBMITTALS
- A. Product Data: For each product indicated.
  - B. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable, and as follows:
    - 1. Areas to be sprinkled.
    - 2. Type of hazards and hazard locations.
    - 3. Type and locations of valves, drains, and test pipes.
    - 4. Alarm devices.
    - 5. Riser diagrams.
    - 6. Fire department connections.
    - 7. Location and coordination of electrical connections.
    - 8. Coordination with other trades.
    - 9. Seismic restraints.

- C. Field test reports and certificates.
- D. Field quality-control test reports.
- E. Operation and maintenance data.
- F. **Submit shop drawings to Insurance Carrier first. Then, submit approved shop drawings to the Indiana Department of Homeland Security for approval. Submit shop drawings bearing stamp of Insurance Carrier and Department of Homeland Security to the Engineer for approval.**
- G. Shop Drawings must be created in a format compatible with AutoCad .dwg extension.

#### 1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test. Work shall be performed by a Sprinkler Contractor engaged in the fire suppression industry for a minimum of five (5) years.
- B. Equipment Qualifications
  - 1. Each item of equipment shall be capable of performing its function over an extended period of time with a minimum of attention and maintenance. All equipment shall be constructed using new materials designed and built in accordance with the best practices of the industry.
  - 2. The equipment manufacturer shall have been engaged in the fire suppression industry for a minimum of five (5) years.
  - 3. All equipment and components shall bear UL and FM label or marking and shall be FM approved for fire service.
- C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
  - 1. FM, "Factory Mutual Approval Guide".
  - 2. UL, "Underwriters Laboratory Fire Protection Equipment Directory.
  - 3. ISU Special Requirements.
  - 4. City of Terre Haute Fire Department requirements.
  - 5. Local, city, state, or any other requirements of the Authority Having Jurisdiction.
  - 6. NFPA 13, "Installation of Sprinkler Systems"; 2010 version.
  - 7. NFPA 14, "Installation of Standpipe, Private Hydrant, and Hose Systems"; 2000 version.

#### 1.06 EXTRA MATERIALS

- A. For Projects requiring more than thirty (30) sprinkler heads, provide 10% extra sprinkler heads and head wrench.
- B. For Projects requiring three (3) or more flow and/or tamper switches, provide 10% (or a minimum of 1) extra for each device.

- C. Provide fifty (50) spare concealed sprinkler head cover plates for the Owner's future use.

#### 1.07 IMPAIRING THE FIRE PROTECTION SYSTEM

- A. Coordinate with Owner all existing fire protection systems.
- B. Use the FM Global Red Tag Regulations.
- C. Plan and coordinate work to minimize the period of time which the system is impaired.
- D. In general, reactivate system at the end of each workday, under the supervision of Facilities Management. System may be left impaired overnight only if explicitly authorized by Owner.

### PART 2 - PRODUCTS

#### 2.01 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping.
- B. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AGF Manufacturing Co.
    - b. Central Sprinkler Corp.
    - c. G/J Innovations, Inc.
    - d. Triple R Specialty of Ajax, Inc.
- C. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. CECA, LLC.
    - b. Merit.

#### 2.02 LISTED FIRE-PROTECTION VALVES

- A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating.
- B. Butterfly Valves: UL 1091.
  - 1. NPS 2 and Smaller: Bronze body with threaded ends.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Global Safety Products, Inc.
    - 2) Milwaukee Valve Company.
  2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with grooved ends.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Central Sprinkler Corp.
      - 2) McWane, Inc.; Kennedy Valve Div.
      - 3) Mueller Company.
      - 4) NIBCO.
      - 5) Victaulic Co. of America.
- C. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Central Sprinkler Corp.
    - b. Crane Co.; Crane Valve Group; Crane Valves.
    - c. Crane Co.; Crane Valve Group; Jenkins Valves.
    - d. Grinnell Fire Protection.
    - e. Hammond Valve.
    - f. McWane, Inc.; Kennedy Valve Div.
    - g. Mueller Company.
    - h. NIBCO.
    - i. Potter-Roemer; Fire Protection Div.
    - j. Reliable Automatic Sprinkler Co., Inc.
    - k. Star Sprinkler Inc.
    - l. Stockham.
    - m. Victaulic Co. of America.
    - n. Watts Industries, Inc.; Water Products Div.
- D. Gate Valves: UL 262, OS&Y type.
  1. NPS 2 and Smaller: Bronze body with threaded ends.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Crane Co.; Crane Valve Group; Crane Valves.
      - 2) Hammond Valve.
      - 3) NIBCO.
  2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Crane Co.; Crane Valve Group; Crane Valves.

- 2) Crane Co.; Crane Valve Group; Jenkins Valves.
- 3) Hammond Valve.
- 4) Milwaukee Valve Company.
- 5) Mueller Company.
- 6) NIBCO.

E. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.

1. Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch.
2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Milwaukee Valve Company.
    - 2) NIBCO.
    - 3) Victaulic Co. of America.
3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
  - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - 1) Central Sprinkler Corp.
    - 2) Grinnell Fire Protection.
    - 3) McWane, Inc.; Kennedy Valve Div.
    - 4) Milwaukee Valve Company.
    - 5) NIBCO.
    - 6) Victaulic Co. of America.

2.03 UNLISTED GENERAL-DUTY VALVES

- A. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.
- B. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
- C. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.04 SPECIALTY VALVES

- A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating.

B. Double-Check Backflow-Prevention Assemblies; DCDV-A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ames Co.
  - b. Watts Industries, Inc.; Water Products Div.
  - c. Zurn Plumbing Products Group; Wilkins Div.
2. Capacity: Size, location, capacity, and model as indicated on Drawings.
3. Standard: ASSE 1015, UL listed and FMG approved, USC approved, Indiana Department of Environmental Management approved.
4. Operation: Continuous-pressure applications, unless otherwise indicated.
5. Body: Cast iron with FDA approved interior lining complying with AWWA C550 or stainless steel. Stainless-steel springs and corrosion resistant materials throughout.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow. Unit consists of two resilient seated full flow isolation valves, two independently operating spring loaded poppet-type check valves.
8. Accessories:
  - a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet. Four resilient seated test cocks for field testing.

2.05 AIR VENT

A. Automatic Air Vent:

1. Description: Automatic air vent that automatically vents trapped air without human intervention.
2. Standard: UL listed or FM Global approved for wet-pipe fire sprinkler systems.
3. Vents oxygen continuously from system.
4. Float valve to prevent water discharge.
5. Minimum Water Working Pressure Rating: 175 psig.

2.06 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Reliable Automatic Sprinkler Co., Inc.
2. Tyco International.
3. Victaulic Co. of America.
4. Viking Corp.

C. Automatic Sprinklers: With heat-responsive element complying with the following:

1. UL 199, for nonresidential applications.

D. Sprinkler Types and Categories:

1. Nominal 1/2-inch orifice for standard flow sprinkler head.
2. Nominal 17/32-inch orifice extended coverage sprinkler head.
3. "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

E. Sprinkler types, features, and options as follows:

1. Concealed ceiling sprinklers, including cover plate.
2. Quick-response sprinklers.
3. Sidewall sprinklers.
4. Upright sprinklers.

F. Sprinkler Finishes: Bronze, painted, custom-color painted where indicated on Drawings.

G. Sprinkler Guards: Wire-cage type when head is installed below 7'-6" or in areas subject to physical damage, including fastening device for attaching to sprinkler.

H. Flexible Sprinkler Hose Fittings:

1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with manufacturer furnished bracket for connection to ceiling grid.
3. Pressure Rating: 175-psig minimum.
4. Size: Same as connected piping, for sprinkler.

## 2.07 HOSE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Central Sprinkler Corp.
2. Elkhart Brass Mfg. Co., Inc.
3. Fire-End and Croker Corp.
4. Grinnell Fire Protection.
5. McWane, Inc.; Kennedy Valve Div.
6. Mueller Company.
7. Potter-Roemer; Fire-Protection Div.

B. Description: UL 668, brass or bronze, 300-psig minimum pressure rating, hose valve for connecting fire hose. Include angle pattern design; female NPS inlet and male hose outlet; and lugged cap, gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2 as indicated, and hose valve threads according to NFPA 1963 and matching local fire department threads.

1. Valve Operation: Nonadjustable type unless pressure-regulating type is indicated.
2. Finish: Polished bronze.

## 2.08 RACK-TYPE HOSE STATIONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Central Sprinkler Corp.
  2. Elkhart Brass Mfg. Co., Inc.
  3. Fire-End and Croker Corp.
  4. Grinnell Fire Protection.
  5. McWane, Inc.; Kennedy Valve Div.
  6. Mueller Company.
  7. Potter-Roemer; Fire-Protection Div.
- B. Hose Rack:
1. Standard: UL 47.
  2. Material: Steel with red-enamel finish.
  3. Type: Hose-rack assembly. Include hose valve, hose rack, water-retention device, hose pins, and hose.
  4. Operation: Semiautomatic.
  5. Sized to hold fire hose.
- C. Hose Valve:
1. Standard: UL 668, NPS 1-1/2, for connecting fire hose.
  2. Hose Valve and Trim Finish: Rough brass or bronze.
  3. Pressure Rating: 300 psig minimum.
  4. Pattern: Angle.
  5. Material: Brass or bronze.
  6. Pressure-Control Device: UL 1468 integral or for field installation if indicated.
  7. Size: NPS 1-1/2.
  8. Inlet: Female pipe threads.
  9. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
- D. Hose:
1. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
  2. Size: NPS 1-1/2.
  3. Length: 50 feet.
  4. Jacket: Synthetic thread.
  5. Lining: Extruded synthetic lining.
  6. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
  7. Nozzle: UL 401.
    - a. Material: Polished brass.
    - b. Type: Spray, adjustable from shutoff to fog spray or straight stream.
- E. Cabinets:
1. Fire-Rated Fire-Protection Cabinets: Listed and labeled to comply with requirements in ASTM E814 for fire-resistance rating of walls where they are installed.

2. Cabinet Material: 20ga. Cold-rolled steel box; 20ga. tubular steel door with 18ga. frame and a continuous steel hinge. All components are powder-coated with an electrostatically-applied, thermally-fused, re-coatable white polyester finish. All glass door styles provided with clear tempered safety glass.
3. Cabinet Mounting:
  - a. Recessed-Mounting with Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface, with exposed trim face and wall return at outer edge (backbend).
  - b. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim.

## 2.09 FIRE DEPARTMENT CONNECTIONS

- A. Freestanding-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; forged aluminum body and powder coat finish, forged aluminum blind cap with powder coat finish, brass identification plate, galvanized steel elbow, 18" high cover sleeve. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads; outlet with NPT pipe threads, and identification base plate with marking similar to "AUTO SPKR & STANDPIPE."
1. Basis-of-Design Product: Subject to compliance with requirements, provide Guardian Fire Equipment 6635 with 6645 cap, or a comparable product by one of the following:
  - a. Elkhart Brass Mfg. Co., Inc.
  - b. Fire-End and Croker Corp.
  - c. Potter Roemer
  - d. Reliable Automatic Sprinkler Co., Inc.
2. Type: Freestanding, with straight pattern, single storz inlet and round identification plate.
3. Finish: Rough chrome finish.

## 2.010 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Electrically Operated Alarm Bell: UL 464, vibrating type with metal alarm bell, 6-inch diameter, cast-aluminum alarm gong with red-enamel factory finish, suitable for outdoor use.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Central Sprinkler Corp.
    - b. Grinnell Fire Protection.
    - c. Reliable Automatic Sprinkler Co., Inc.
    - d. Star Sprinkler Inc.
    - e. Viking Corp.

- C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ADT Security Services, Inc.
    - b. Grinnell Fire Protection.
    - c. ITT McDonnell & Miller
    - d. Potter Electric Signal Company.
    - e. System Sensor.
    - f. Viking Corp.
    - g. Watts Industries, Inc.; Water Products Div.
- D. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. McWane, Inc.; Kennedy Valve Div.
    - b. Potter Electric Signal Company.
    - c. System Sensor.

### PART 3 - EXECUTION

#### 3.01 GENERAL

- A. Inspect preceding work. Verify all dimensions before proceeding with work and coordinate all work and placement of components with other trades.
- B. Be responsible for all measurements, fitting and assembly of all work. Prefabrication is done at the Contractor's risk.
- C. Installation
  1. Drawings indicate general intent and location. Piping shall be installed in the most direct and straight manner as possible. All lines shall be run high enough to permit relocation of lights without moving ceiling grid.
  2. Coordinate exact pipe locations with Drawings and other trades before design approval and fabrication of piping. This Contractor shall be responsible for any redesign and fabrication required to fit system into allowable space.
  3. Do not route any piping over electrical panels, transformers, or other equipment requiring a clear space above per NEC and NFPA Codes.
  4. All piping in finished areas shall be concealed unless shown otherwise on the Drawings.
  5. All vertical lines shall be plumb and horizontal lines shall run parallel to building construction.

6. Install horizontal piping to slope to low points so that entire system may be emptied to facilitate testing.
7. Pipe drains to terminate outside the building wherever possible. Location of drains to the building exterior shall be as shown on Drawings or as approved by the Owner.
8. Pipe and fittings shall be inspected for soundness and cleaned of all dirt and other foreign matter prior to be installed. All damaged pipe and fittings will be rejected.
9. Protect open pipe ends whenever work is suspended during construction to prevent foreign material from entering.
10. Chrome plated or other polished finished components shall be installed with care so that marring does not occur to the finish.

D. Zoning

1. Sprinkler system shall be zoned on a floor-by-floor basis. In addition, systems protecting special hazards shall be zoned separately.
2. Refer to Drawings for sprinkler zone locations.

E. Connection To Utilities

1. Contractor shall make all connections to utilities as required to install the system. All connections to utilities and their shutdown shall be arranged with the Owner. Existing system(s) will be shutdown and drained by the Contractor.

F. Pipe Supports

1. All piping shall be supported from the structure above with UL approved hangers. Sizing, spacing, and installation shall be in accordance with NFPA 13 except as otherwise shown on the Drawings or specified herein. Comply with other sections of this specification relating to Basic Mechanical Materials and Methods for basic pipe installation.
2. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 250 lb.

G. Backflow Preventers

1. Install in compliance with state regulations. Mount horizontal, maximum 4 ft. above the floor.
2. Test backflow preventer to ensure proper operation. Inspection shall be performed by a registered inspector in accordance with the Indiana Department of Environmental Management. Submit reports to the Owner and include a copy in the Operation and Maintenance manuals.

H. Fire Department Inlet Connection

1. Provide a check valve with ball drip valve in line connecting fire department connection to fire protection system.

I. Inspectors Test Connection

1. Inspector test connections shall be installed at the most remote point of each sprinkler zone system. Test connections shall be provided with a 1" pipe and valve. Test pipe shall discharge to the outside through a corrosion resistant orifice of the proper size, where it can easily be seen. Location of discharge shall be as approved by the Owner.

J. Ball Drip Valves

1. Provide where shown and as required. Locate ball drips in accessible locations and pipe discharge full size to nearest floor drain.

K. Valve Supervisory Switches

1. Provide valve supervisory switches for all water supply shut-off valves.

L. Sprinkler Heads

1. Sprinkler heads shall be installed per manufacturer's recommendations. Heads shall be installed to satisfy all code requirements for head spacing and as herein specified.
2. Finishes shall be protected against scratches, dents and discoloration. Defective items will not be acceptable.

M. Wet Sprinkler System

1. Fire sprinklers shall be provided for the entire building except as follows:
  - a. Do not install sprinkler piping or heads in elevator shafts or elevator equipment rooms.
2. **Air Vent:**
  - a. **Provide at least one air vent in each wet pipe sprinkler system in accordance with NFPA 13 requirements. Connect vent into top of fire sprinkler piping. Where trapped portion of pipe exists, provide air vent for each location.**
  - b. **Provide dielectric union for dissimilar metals, ball or globe valve, and strainer upstream of automatic air vent.**

N. Standpipe System(s)

1. Provide a Class I manual-wet standpipe in accordance with NFPA 14 - 2000. System shall be hydraulically designed to provide the required minimum pressure and flow rate.
2. Standpipes shall be installed in each stairway and where shown on the Drawings.
3. Provide a 2-1/2" hose valve at the following locations. Valve shall be installed 4 ft. above the floor unless shown otherwise on the Drawings.
  - a. At each intermediate landing between floor levels in every stairway.
  - b. At the highest landing of stairways with stairway access to the roof.
  - c. Elsewhere as shown on the Drawings.
4. At each standpipe where stairway does not access the roof, provide a roof manifold when the roof has a slope of less than 4" in 12". Where lines pass through the roof, provide flashing and counterflashing as required for a watertight installation.

5. All standpipes shall be interconnected at the bottom. Provide isolation valve at all risers.
6. Provide drain valves with hose connection at the low point of all standpipes downstream of the isolation valve.

O. Instructions

1. When required approvals of this work have been obtained, and at time designated by the Owner, demonstrate to the Owner's personnel the operation and maintenance of the systems.

3.02 PIPING INSTALLATION

- A. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for basic piping installation.
- B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
  1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- C. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.
- E. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install drain valves on standpipes.
- I. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
- J. Install alarm devices in piping systems.
- K. Hangers and Supports: Comply with NFPA 13 for hanger materials.
  1. Install standpipe system piping according to NFPA 14.
  2. Install sprinkler system piping according to NFPA 13.
- L. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.

- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- N. Fill wet-standpipe system piping with water.
- O. Fill wet-pipe sprinkler system piping with water.

### 3.03 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
  - 1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13 and NFPA 14.
    - a. Shutoff Duty: Use butterfly or gate valves.
  - 2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13 and NFPA 14.
    - a. Shutoff Duty: Use butterfly or gate valves.
    - b. Throttling Duty: Use globe valves.

### 3.04 VALVE INSTALLATION

- A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and NFPA 14 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install backflow preventers in potable-water supply sources.

### 3.05 SPRINKLER APPLICATIONS

- A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
  - 1. Rooms without Ceilings: Upright sprinklers.
  - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
  - 3. Wall Mounting: Sidewall sprinklers.
  - 4. Sprinkler Finishes:
    - a. Upright Sprinklers: Rough bronze.
    - b. Concealed Sprinklers: Rough brass, with factory-painted cover plate. Finish shall be white unless custom-color cover plate is indicated on Drawings.

3.06 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of both dimensions of acoustical ceiling panels and tiles.

3.07 HOSE-CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes, unless otherwise indicated.
- B. Install freestanding hose connections for access and minimum passage restriction.

3.08 HOSE-STATION INSTALLATION

- A. Install hose-reel hose stations on wall with bracket.
- B. Install hose stations with clear access and minimum passage restriction.
- C. Install NPS 1-1/2 hose-station valves with flow-restricting device unless otherwise indicated.
- D. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose.
  - 1. Prepare recesses for fire-protection cabinets as required by type and size of cabinet and trim style.
  - 2. Install fire-protection cabinets in locations and at mounting heights indicated, or at heights acceptable to authorities having jurisdiction.
  - 3. Fire-Protection Cabinets: Fasten cabinets to structure, square and plumb.
  - 4. Identification: Apply decals at locations indicated.
  - 5. Adjust fire-protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.

3.09 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install freestanding-type, fire department connections in level surface.
  - 1. Install protective pipe bollards on three sides of each fire department connection. Refer to Division 05 Section "Metal Fabrications" for pipe bollards.
- B. Install ball drip valve at each check valve for fire department connection.

3.010 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect water-supply piping to fire-suppression piping.

- D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
- F. Electrical Connections: Power wiring is specified in Division 26.
- G. Connect alarm devices to fire alarm.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.011 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
  - 3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
  - 4. Coordinate with fire alarm tests. Operate as required.
  - 5. Verify that equipment hose threads are same as local fire department equipment.
- B. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- C. Sterilization
  - 1. Contractor shall sterilize all piping upstream of fire protection backflow preventer.
    - a. Flush system thoroughly until water runs clear.
    - b. Entire system shall be filled with a water/chlorine solution containing 50 parts per million of chlorine. The system or part thereof shall be valved off and allowed to stand for 24 hours; or the system or part thereof shall be filled with a water/chlorine solution containing at least 200 parts per million of chlorine and allowed to stand for three hours.
    - c. Following the allowed standing time, the system shall be flushed with clean potable water until chlorine does not remain in the water coming from the system.
    - d. After the above requirements are satisfied, submit samples to Indiana State Board of Health for approval.
    - e. Sterilization shall be redone until approval from the State Board of Health is obtained. Include copies of the approval in the Operations and Maintenance Manuals.
- D. Testing
  - 1. Testing to comply with NFPA 13 Standard.

2. Test backflow preventer to ensure proper operation. Inspection shall be performed by a registered inspector in accordance with the Indiana Department of Environmental Management. Submit reports to the Owner and include a copy in the Operations and Maintenance manuals.
3. Test all piping hydrostatically at not less than 200 psi for 2 hours without loss of pressure.
4. Retest piping that initially fails after corrective actions have been made.
5. All tests shall be made in the presence of the Owner's Representative or as directed by the Engineer. Allow for at least 24 hour notice of all tests.
6. Complete and sign "Contractor's Material and Test Certificates". Make arrangements and pay for all costs for all inspections by the authority having jurisdiction and obtain approval of the installation. Include copies of the certificates in the Operations and Maintenance Manuals.

END OF SECTION 21 10 00

## SECTION 221119 – DOMESTIC WATER SPECIALTIES

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following domestic water piping specialties: **(select as required)**

1. Backflow preventers.
2. Balancing valves.
3. Thermostatic zone valves.
4. Temperature-actuated water mixing valves.
5. Expansion tanks.
6. Strainers.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water hammer arresters.

#### 1.02 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

#### 1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

#### 1.04 QUALITY ASSURANCE

- A. NSF Compliance:
1. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

## PART 2 - PRODUCTS

### 2.01 BACKFLOW PREVENTERS

#### A. Reduced-Pressure-Principle Backflow Preventers; RPZ-A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ames Co.
  - b. Watts Industries, Inc.; Water Products Div.
  - c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Capacity: Size, location, capacity, and model as indicated on Drawings.
5. Body: Cast iron with FDA approved epoxy lining complying with AWWA C550.
6. End Connections: Flanged.
7. Configuration: Designed for horizontal, straight through flow.
8. Relief Valve: Designed to admit air directly into the reduced pressure zone via separate channel from the water discharge.
9. Accessories:
  - a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
  - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
  - c. Strainer: FDA approved epoxy coated strainer.

### 2.02 BALANCING VALVES

#### A. Memory-Stop Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett Circuit Setter Plus or a comparable product by one of the following:
  - a. Hammond Valve.
  - b. Milwaukee Valve Company.
  - c. NIBCO INC.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: Equal to pipe-size.
5. Body: Copper alloy with 1/4-inch NPT tapped drain/purge port.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device. Nameplate to be calibrated to assure specific setting.
11. Operation: Dial-set balancing device. Valve to have differential pressure read-out ports across seat area and memory stop feature to allow it to be closed for service and then reopened to set point without disturbing balance position.

## 2.03 THERMOSTATIC ZONE VALVES

### A. Thermostatic Zone Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Acorn TZV-2, or approved equal.
2. Construction: Lead-free certified DZR brass body with corrosion resistant and lead-free internal components. It shall include an integral cartridge-style check valve with accessible screens to prevent backflow and to filter debris from entering the valve.
3. Temperature: Factory set to 110°F. Valve is field adjustable from 100°F to 160°F and is made using an allen wrench and a lockout nut on the bonnet to prevent unauthorized or accidental temperature adjustment.
4. Thermostatic: Commercial quality paraffin actuator.
5. Options (shipped unassembled for field installation):
  - a. Three (3) ball shutoff valves.
  - b. Inlet temperature gauge.
  - c. Pipe union.
6. Operation: Valve shall proportionally modulate to maintain zone temperature based on heat loss and shall stabilize pump demand to prevent cycling.

## 2.04 TEMPERATURE-ACTUATED WATER MIXING VALVES

### A. Primary, Thermostatic, Water Mixing Valves; TMV-A:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Armstrong "The Brain" digital water control valve.
2. Capacity: Size, location, capacity, and model as indicated on Drawings.
3. General: Temperature controller shall be controlled digitally via integrated circuit board technology designed to deliver blended water.
4. Materials of Construction:
  - a. Digital recirculating valve
  - b. 100-240V power supply (12 VAC output)
  - c. 2 x 4-20 mA current loop interfaces
    - 1) Input: Setpoint selection
    - 2) Output: Measured blend temperature
  - d. Relay output: 24V
    - 1) Error relay: Activated in error mode
  - e. Serial connection port
  - f. Optional external network adapter (SAGE)
  - g. All stainless steel construction
  - h. 1" NPT connections

5. Performance

- a. The digital recirculation valve (DRV) shall deliver rated flow with no minimum system draw-off requirement.
- b. Setpoint configuration, unit selection, alarm condition available via Bluetooth connectivity or via the Building Automation System.
- c. The temperature controller shall be compliant with ASSE 1017 and CSA B125.

6. The DRV shall include all of the following capabilities:

- a. Accurate control of blended water drawn from the system at a point of use within +/- 2°F at draw off points a minimum of 5m downstream of mixing valve during consistent system demand periods.
- b. Operational water pressure of 0-150 psig.
- c. Minimum valve inlet to outlet temperature requirement of 2°F.
- d. Automatic shutoff of hot water flow upon cold water inlet supply failure.
- e. Automatic shutoff of hot water flow in the event of a power failure.
- f. Maintain a consistent system "idling" temperature and control "temperature creep" without the use of manual throttling device or balance valve.
- g. Programmable setpoint range of 100-160°F.
- h. Recirculation system manifold comprising of the following:
  - 1) System return check valve.
  - 2) Return to heater check valve.
  - 3) Return to heater ball flow indicator.
  - 4) Cold water check valve.
- i. Programmable 1<sup>st</sup> level hi/lo temp alarm display.
- j. Programmable 2<sup>nd</sup> level hi/lo temp alarm display/full cold.

2.05 EXPANSION TANKS

A. Thermal Expansion Tank; ET-A:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Amtrol.
  - b. Bell & Gossett.
  - c. Calefactio
  - d. Taco.
- 2. Capacity: Size, location, capacity, and model as indicated on Drawings.
- 3. Pressure Rating: 150 psig maximum working pressure.
- 4. Construction: Diaphragm type expansion tank with polypropylene liner, or full acceptance bladder type.
- 5. Tank: Welded steel with stainless steel system connection.
- 6. Factory charge: 40 psig, field adjustable.
- 7. Finish: Resistant electrostatic paint, beige color.

## 2.06 STRAINERS FOR DOMESTIC WATER PIPING

### A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with FDA-approved interior lining complying with AWWA C550 for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
  - a. Strainers NPS 2 and Smaller: 0.020 inch.
  - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
  - c. Strainers NPS 5 and Larger: 0.100 inch.
6. Drain: Factory-installed, hose-end drain valve.

## 2.07 HOSE BIBBS

### A. Hose Bibbs; HB-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Woodford Model 24 or a compatible product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Brass.
4. Seat: Standard 'O' size washer, replaceable. Quarter-turn valves and/or ceramic cartridge valves are not acceptable.
5. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish: Rough brass.
10. Operation: Optional metal wheel handle.

## 2.08 WALL HYDRANTS

### A. Non-freeze Wall Hydrants; HYD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Woodford Model B65 or a compatible product by one of the following:
  - a. Josam Company.
  - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Body Material: Brass.
4. Seat: Standard 'O' size washer, replaceable. Quarter-turn valves and/or ceramic cartridge valves are not acceptable.
5. Pressure Rating: 125 psig.
6. Operation: Self draining design with a drainage tube that is pitched to the faceplate to provide positive drainage when water is shut off. Single tube hydrants that require the installation to be sloped to the exterior wall are not acceptable.
7. Operating Rod: Solid brass rod, of length required to match wall thickness.
8. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
9. Outlet Connection: Concealed, with garden-hose thread complying with ASME B1.20.7.
10. Vacuum Breaker: Integral, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
11. Box: Cast brass, flush mounting with cover.
12. Box and Cover Finish: Chrome plated.
13. Wall Clamp: Required.
14. Operating Keys(s): One with each wall hydrant.

## 2.09 DRAIN VALVES

### A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

## 2.010 WATER HAMMER ARRESTERS

### A. Water Hammer Arresters; WHA:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. AMTROL, Inc.
  - b. Josam Company.
  - c. PPP Inc.
  - d. Sioux Chief Manufacturing Company, Inc.
  - e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - f. Tyler Pipe; Wade Div.
  - g. Watts Drainage Products Inc.
  - h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Stainless-steel bellows with factory pressurized and sealed cushion chamber.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
  1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
  2. Do not install bypass piping around backflow preventers.
- C. Install balancing valves in locations where they can easily be adjusted.
- D. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
- E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

- F. Install water hammer arresters in water piping as follows:
  - 1. In accordance to PDI-WH 201.
  - 2. In upright position.
  - 3. At any fixture having quick-closing valves.
  - 4. In an accessible location. Provide access panels as required. Coordinate with Architectural Drawings.
- G. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping and specialties.

### 3.02 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
  - 1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Test domestic water piping specialties under pressure. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for pressure test requirements.
- C. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

### 3.03 ADJUSTING

- A. Set field-adjustable temperature set points of temperature-actuated water mixing valves. Test setting at full hot water system flow, and at zero hot water system flow. Adjust heating system balance valve so that temperature does not increase or decrease under maximum and minimum design conditions.
- B. Adjust expansion tank pre-charge pressure (40 psig) to match water system pressure.

END OF SECTION 22 11 19

## SECTION 221123 – DOMESTIC CIRCULATION PUMPS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following all-stainless steel centrifugal pumps for domestic hot-water circulation:

- 1. Close-coupled, horizontally mounted, in-line centrifugal pumps.

#### 1.02 SUBMITTALS

- A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.
- C. NSF Compliance: Comply with NSF 61-G for motor-operated water pumps.

### PART 2 - PRODUCTS

#### 2.01 CLOSE-COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Circulation Pump; CP-A:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong Pumps Inc.
    - b. Bell & Gossett Domestic Pump; ITT Industries.
    - c. Taco.
  - 2. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.

3. Pump Construction: All stainless steel.
  - a. Casing: Radially split, stainless steel, with threaded companion-flange connections for pumps with NPS 2 and smaller pipe connections.
  - b. Impeller: Stainless steel; statically and dynamically balanced, closed, and keyed to shaft.
  - c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
  - d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
  - e. Bearings: Oil-lubricated; bronze-journal or ball type.
  - f. Capacity: Size, location, capacity, and model as indicated on Drawings.
4. Shaft Coupling: Rigid type if pump is provided with coupling.
5. Motor: Single speed, with grease-lubricated ball bearings.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Install close-coupled, horizontally mounted, in-line centrifugal pumps with motor and pump shafts horizontal.
- E. Install continuous-thread hanger rods and/or fabricate brackets as required. Hanger and support materials are specified in Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC."
- F. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- G. Install piping adjacent to pumps to allow service and maintenance.
- H. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC."
1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for general-duty valves for domestic water piping and for strainers.

2. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 20 Section "Common Materials and Methods for Fire Suppression, Plumbing, and HVAC" for pressure gages and gage connectors.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 22 11 23

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## SECTION 221319 – WASTE SPECIALTIES

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:

1. Cleanouts.
2. Floor drains.
3. Floor sinks.

#### 1.02 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

#### 1.03 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

### PART 2 - PRODUCTS

#### 2.01 CLEANOUTS

- A. Cleanouts for Vinyl Tile Floor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4141S or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron
5. Outlet Connection: Spigot.
6. Closure: Bronze plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with threads.
8. Frame and Cover Material and Finish: Nickel-bronze with 1/8 inch tile recess.
9. Frame and Cover Shape: Round.
10. Top Loading Classification: Light duty.

B. Cleanouts for Terrazzo Floor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4181S or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron
5. Outlet Connection: Spigot.
6. Closure: Bronze plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with threads.
8. Frame and Cover Material and Finish: Nickel-bronze with 1/2 inch terrazzo recess.
9. Frame and Cover Shape: Round.
10. Top Loading Classification: Light duty.

C. Cleanouts for Carpet Floor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4021S-Y or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron
5. Outlet Connection: Spigot.
6. Closure: Bronze plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with threads.
8. Frame and Cover Material and Finish: Scoriated nickel-bronze with carpet marker.
9. Frame and Cover Shape: Round.
10. Top Loading Classification: Light duty.

D. Cleanouts for Concrete Floor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4101S or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron
5. Outlet Connection: Spigot.
6. Closure: Bronze plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with set-screws.

8. Frame and Cover Material and Finish: Scoriated nickel-bronze.
9. Frame and Cover Shape: Round.
10. Top Loading Classification: Extra heavy duty.

E. Exterior Cleanouts:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4251S or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.
4. Body or Ferrule: Cast iron cleanout and cast iron double flanged housing.
5. Outlet Connection: Spigot.
6. Closure: Bronze plug with straight threads and gasket.
7. Frame and Cover Material and Finish: Scoriated cast iron with lifting device.
8. Frame and Cover Shape: Round.
9. Top Loading Classification: Heavy duty.

F. Wall Cleanouts:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 4531S-Y or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping.
4. Body: Hub-less, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded bronze plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

## 2.02 FLOOR DRAINS

### A. Cast-Iron Floor Drains; FD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 2041S-A or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Combination flashing collar and clamp with seepage openings.
6. Outlet: Side, spigot.
7. Coating on Interior and Exposed Exterior Surfaces: Not required.
8. Sediment Bucket: Not required.
9. Top or Strainer Material: Nickel bronze.
10. Top Description: Adjustable, round, heel-proof, flat.
11. Top Loading Classification: Light Duty.
12. Trap Material: Cast iron.
13. Trap Pattern: Integral deep-seal P-trap.
14. Trap Features: Cleanout.

### B. Cast-Iron Floor Drains; FD-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 2005Y-A or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Combination flashing collar and clamp with seepage openings.
6. Outlet: Bottom, no-hub.
7. Coating on Interior and Exposed Exterior Surfaces: Not required.
8. Sediment Bucket: Not required.
9. Top or Strainer Material: Nickel bronze.
10. Top Description: Adjustable, round, heel-proof, flat.
11. Top Loading Classification: Light Duty.

C. Cast-Iron Floor Drains; FD-3:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 3030Y or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Combination flashing collar and clamp with seepage openings.
6. Outlet: Bottom, no-hub.
7. Coating on Interior and Exposed Exterior Surfaces: Acid resistant coated interior.
8. Sediment Bucket: Bottom dome aluminum strainer.
9. Top or Strainer Material: Nickel bronze.
10. Top Description: Round, flat.
11. Top Loading Classification: Medium Duty.

2.03 FLOOR SINKS

A. Cast-Iron Floor Sinks; FS-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 3150Y-12 or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Pattern: 8-inch deep floor sink.
4. Body Material: Gray iron.
5. Seepage Flange: Flanged receptor with seepage openings.
6. Outlet: Bottom, no-hub.
7. Coating on Interior and Exposed Exterior Surfaces: Acid resistant coating.
8. Sediment Bucket: Bottom dome aluminum strainer.
9. Top or Strainer Material: Nickel bronze.
10. Top Description: 1/2 grate with nickel bronze rim.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for piping joining materials, joint construction, and basic installation requirements.

- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
  - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
  - 2. Locate at each change in direction of piping greater than 45 degrees.
  - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
  - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
  - 1. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
  - 2. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

### 3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

### 3.03 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 19

## SECTION 221423 – STORM SPECIALTIES

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following storm drainage piping specialties:

1. Cleanouts.
2. Area drains.
3. Roof drains.
4. Miscellaneous storm drainage piping specialties.

#### 1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.

#### 1.03 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

### PART 2 - PRODUCTS

#### 2.01 CLEANOUTS

- A. Refer to Section 221319 for cleanout products.

#### 2.02 AREA DRAINS

- A. Cast-Iron Area Drains; AD-1:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 2230Y-NB or a comparable product by one of the following:
    - a. Josam Company; Josam Div.
    - b. Watts Drainage Products Inc.
    - c. Zurn Plumbing Products Group; Light Commercial Operation.
  2. Standard: ASME A112.6.3.
  3. Body Material: Gray iron.
  4. Seepage Flange: Combination flashing collar and clamp with seepage openings.
  5. Outlet: Bottom, no-hub.
  6. Sediment Bucket: Safe-Set bucket required.
  7. Top or Strainer Material: Nickel bronze.
  8. Top Description: Round, bar-grate, flat.
  9. Top Loading Classification: Medium Duty.

## 2.03 ROOF DRAINS

### A. Cast-Iron Roof Drains; RD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 1015Y-C-R-CID or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.21.2M.
3. Body Material: Cast iron.
4. Combination Flashing Ring and Gravel Stop: Required.
5. Flow-Control Weirs: Not required.
6. Outlet: Bottom, No-hub.
7. Dome Material: Cast iron.
8. Adjustable Extension Collars: Required.
9. Underdeck Clamp: Required.
10. Sump Receiver: Required.

### B. Cast-Iron Overflow Roof Drains; ORD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 1045Y-C-R-CID or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.21.2M.
3. Body Material: Cast iron.
4. Combination Flashing Ring and Gravel Stop: Required.
5. Flow-Control Weirs: 2" exterior water dam required.
6. Outlet: Bottom, No-hub.
7. Dome Material: Cast iron.
8. Adjustable Extension Collars: Required.
9. Underdeck Clamp: Required.
10. Sump Receiver: Required.

## 2.04 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

### A. Conductor Nozzles:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 1770Y or a comparable product by one of the following:
  - a. Josam Company; Josam Div.
  - b. Watts Drainage Products Inc.
  - c. Zurn Plumbing Products Group; Light Commercial Operation.
2. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.

3. Size: Same as connected conductor.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Refer to Division 20 Section "Common Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC." for piping joining materials, joint construction, and basic installation requirements.
- B. Refer to Section 221319 for cleanout installation requirements.
- C. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roof materials are specified in Division 07.
  1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
  2. Position roof drains for easy access and maintenance.
- D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

#### 3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

#### 3.03 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 14 23

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## PART 1 - GENERAL

### 1.1 SUMMARY

- A. This Section includes the following sump pumps and accessories for storm drainage piping systems in buildings:
  - 1. Submersible sump pumps.

### 1.2 SUBMITTALS

- A. Product Data: For each type and size of sump pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

### 1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## PART 2 - PRODUCTS

### 2.1 SUBMERSIBLE SUMP PUMPS

- A. Sump Pump; SP-A:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Zoeller Pump Company, Inc.
    - b. Hydromatic Pump.
  - 2. Description: Factory-assembled and -tested, simplex, single-stage, centrifugal, end-suction, submersible, direct-connected sump pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sump pumps.
  - 3. Casing: Cast iron, with suction strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.
  - 4. Impeller: Engineered thermoplastic; non-clog vortex design and capable of handling 3/4" solids; overhung, single suction, and keyed and secured to shaft.
  - 5. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings, carbon-ceramic mechanical seals.

6. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
  - a. Motor Housing Fluid: Oil.
- B. Pump Discharge Piping: Schedule 80, ASTM D1785 PVC pipe.
- C. Controls
  1. NEMA 250, Type 1 polycarbonate enclosure with the following features:
    - a. Hand-run buttons
    - b. Pump run lights
    - c. Test/silence push button
    - d. Alarm light
    - e. Elapsed time meters
    - f. Single-pole float level switches (3)
    - g. High-water alarm
    - h. One (1) set of dry contacts for connection to building management system

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install sump pumps according to applicable requirements in HI 1.4.
- B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.
- C. Set submersible sump pumps in elevator sump.
- D. Support piping so weight of piping is not supported by pumps.
- E. Piping installation requirements are specified in Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC." Drawings indicate general arrangement of piping, fittings, and specialties.
- F. Connect discharge piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC."
  1. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for general-duty valves for sanitary waste piping.

- G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 22 14 29

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## SECTION 221519 – AIR COMPRESSORS AND RECEIVERS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. Section Includes:
  - 1. Lubricated, reciprocating air compressors.
  - 2. Inlet air filters.
  - 3. Pre-filters.
  - 4. Filter regulators.
  - 5. Hose reels.

#### 1.02 RELATED DOCUMENTS

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

#### 1.03 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Diagrams for power, signal, and control wiring.
- C. Operation and maintenance data.
- D. Warranty.

#### 1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

## 1.05 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures.
    - b. Faulty operation of controls.
    - c. Deterioration of metals, finishes, and other materials beyond normal use.
  - 2. Warranty Period(s): From date of Substantial Completion:
    - a. Lubricated, reciprocating air compressors: 2-years.

## PART 2 - PRODUCTS

### 2.01 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

- A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
- B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
  - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
  - 2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
  - 3. Control Voltage: 120-V ac or less, using integral control power transformer.
  - 4. Motor Overload Protection: Overload relay in each phase.
  - 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
  - 6. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
- C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - 1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
  - 2. Interior Finish: Corrosion-resistant coating.
  - 3. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.
- D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

## 2.02 RECIPROCATING AIR COMPRESSORS

### A. Lubricated, Reciprocating Air Compressors; AC-A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ingersoll Rand
  - b. Powerex.
  - c. Quincy.
  - d. Champion.
  - e. Sullair.
2. General:
  - a. Capacity: Size, location, capacity, and model as indicated on Drawings.
3. Air Compressor: Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
  - a. Cast iron construction.
  - b. Two-stage design.
  - c. Belt guard totally enclosing pulleys and belts.
  - d. Premium package including the following accessories:
    - 1) Combined high discharge-air temperature and low lubrication-oil pressure switch.
    - 2) ODP motor.
    - 3) Magnetic motor starter.
    - 4) Automatic start/stop control with pressure switch.
    - 5) Automatic electric drain.
    - 6) Air-cooled aftercooler.
4. Receiver: ASME construction steel tank.
  - a. Arrangement: Vertical.
  - b. Interior Finish: Epoxy coating.
  - c. Drain: Automatic valve.

## 2.03 INLET-AIR FILTERS

- ### A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
  2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

## 2.04 PRE-FILTER

### A. Pre-Filter:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
  - a. Beko Technologies, Clearpoint 3eco series.
  - b. ARO Fluid Handling.
2. Construction:
  - a. Anodized aluminum housing, secured slide feed, double-implemented trapezoidal thread.
3. Filter:
  - a. Grade F (Fine).
  - b. One (1) micron.
  - c. 25\* filter size.
  - d. 0.1 mg/m<sup>3</sup> maximum oil carry-over.
  - e. Push-fit element replacement design.

## 2.05 FILTER REGULATOR

### A. Filter Regulator:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
  - a. ARO Fluid Handling, 2000 series "Piggyback" filter-regulator.
  - b. Approved equal.
2. Construction:
  - a. Anodized aluminum body.
  - b. Aluminum bowl with manual drain and sight glass.
  - c. Manufacturer furnished wall mounting bracket.
3. Filter: 0.3 micron coalescing type.
4. Regulator: 0-140 psi pressure range with flush mounted gauge

## 2.06 HOSE REEL

### A. Hose Reel:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
  - a. ARO Fluid Handling.
  - b. Approved equal.

2. Construction:

- a. Powder coated steel frame, base plate and hub fabricated with strength beads and rolled edges for extra strength and rigidity.
- b. Heavy duty latch spring that can be replaced without removing or disassembling the hose reel.
- c. Steel axle with self-lubricating bearings.
- d. Multi-position guide arm for ceiling, floor, or wall mounting.
- e. 300 psi maximum working pressure.
- f. Hose information:
  - 1) 3/8" hose I.D.
  - 2) 1-wire braid type.
  - 3) 1/2 – 14 n.p.t.f. – 1(m) 90° x 1/4 – 18 n.p.t.f. – 1(m) thread size.
  - 4) Length as indicated on Drawings.
- g. Accessories:
  - 1) ARO 77763-1 coupling.
  - 2) ARO 5671 hose stop.

PART 3 - EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Equipment Mounting:

1. Install air compressors and receivers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified herein.
2. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
4. Install equipment to allow right-of-way for piping installed at required slope.
5. Comply with requirements for vibration isolation and seismic control devices specified in Section 20 00 50 "Common Materials & Methods for Fire Suppression, Plumbing & HVAC".

B. Install compressed-air equipment anchored to substrate.

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Install the following devices on compressed-air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors.
3. Automatic Drain Valves: Install where shown on Drawings and specified herein. Discharge condensate over nearest floor drain.

### 3.02 CONNECTIONS

- A. Refer to Division 20 Section, "Common Pipe, Valves & Fittings for Fire Suppression, Plumbing & HVAC" for piping, joining materials, joint construction, and basic installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for piping specified herein.
- C. Where installing piping adjacent to machine, allow space for service and maintenance.
- D. Connect compressed air piping to compressed air equipment, accessories, and specialties with shutoff valve and union connection.

### 3.03 IDENTIFICATION

- A. Identify general-service air compressors and components. Comply with requirements for identification specified in Section 20 00 50 "Common Materials and Methods for Fire Suppression, Plumbing and HVAC."

### 3.04 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to inspect installation, including connections, and to assist in field testing.
- B. Perform the following field tests and inspections:
  - 1. Leak Test: After installation, charge the system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace compressed-air equipment that does not pass tests and inspections and retest as specified above.

### 3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors, air dryers, controllers and related equipment. Refer to Division 01 Section "Demonstrating and Training."
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check for lubricating oil.
  - 3. Check belt drives for proper tension.
  - 4. Verify that air compressor inlet filters and piping are clear.
  - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
  - 6. Check safety valves for correct settings. Ensure that settings are higher than air compressor discharge pressure, but not higher than rating of system components.
  - 7. Check for proper seismic restraints.

8. Drain receiver tank.
  9. Operational test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  10. Test and adjust controls and safeties.
- B. Prepare written report documenting testing procedures and results.

END OF SECTION 22 15 19

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## SECTION 223100 – WATER SOFTENERS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:

1. Water Softeners
2. Chemicals.
3. Water testing kits.

#### 1.02 SUBMITTALS

- A. Product Data: For each type of water softener and water testing kit indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and connections to piping systems.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For water softeners to include in emergency, operation, and maintenance manuals.
- E. Warranty: Special warranty specified in this Section.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

#### 1.04 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softener that fail in materials or workmanship within specified warranty period.
1. Water Softener, Warranty Period: Five years from date of Substantial Completion.

1.05 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Salt for Brine Tanks: Furnish same form as, up to 2500 lb, as required to fill brine tank. Deliver on pallets in 40- or 50-lb packages.
  2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

PART 2 - PRODUCTS

2.01 COMMERCIAL WATER SOFTENERS

- A. Pressure-type water softener; WS-A:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Aqua Systems\*.
    - b. Culligan International Company\*.
    - c. Marlo, Inc\*.

\* All systems shall use Fleck control valves.
  2. General:
    - a. Comply with NSF 61, "Drinking Water System Components--Health Effects."
    - b. Capacity: Size, location, capacity, and model as indicated on Drawings.
    - c. Configuration: Single unit with one mineral tank and one brine tank.
  3. Mineral Tank: Fiberglass reinforced polyester; pressure-vessel quality.
    - a. Construction: The mineral tank shall be "polyglass" consisting of an inner shell of virgin polyethylene and an external shell of continuous fiberglass roving.
    - b. Pressure Rating: 150 psig minimum.
    - c. Wetted Components: Suitable for water temperatures from 40 to at least 120 deg F.
    - d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
    - e. Support Legs or Skirt: Constructed of PVC, bonded to tank before testing and labeling.
    - f. Upper Distribution System: Single, point type, fabricated from PVC pipe and fittings.
    - g. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, non-clogging PE strainers; arranged for even flow distribution through resin bed.
  4. Controls: Fully automatic; factory mounted on unit and factory wired.
    - a. Adjustable duration of various regeneration steps.
    - b. Push-button start and complete manual operation.

- c. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.
  - d. Pointer on pilot-control valve shall indicate cycle of operation.
  - e. Means of manual operation of pilot-control valve if power fails.
  - f. Main Operating Valves: Automatic, multiport, diaphragm type with the following features:
    - 1) Slow opening and closing, non-slam operation.
    - 2) Diaphragm guiding on full perimeter from fully open to fully closed.
    - 3) Isolated dissimilar metals within valve.
    - 4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
    - 5) Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
    - 6) Sampling cocks for soft water.
    - 7) Special tools are not required for service.
  - g. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.
    - 1) Demand-Initiated Control: Equip mineral tank with automatic-reset-head water meter in outlet header that electrically activates cycle controller to automatically regenerate mineral tank at preset total in gallons. Include electrical lockout to prevent regeneration during normal business hours.
5. Brine Tank: Combination measuring and wet-salt storing system.
- a. Tank and Cover Material: Molded PE, 3/8 inch thick.
  - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
  - c. Size: Large enough for at least four regenerations at full salting.
6. Factory-Installed Accessories:
- a. Piping, valves, tubing, and drains.
  - b. Sampling cocks.
  - c. Main-operating-valve position indicators.
  - d. Water meters.

## 2.02 CHEMICALS

- A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
  - 1. Exchange Capacity: 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.
- B. Salt for Brine Tanks: High-purity sodium chloride; free of dirt and foreign material. Rock and granulated forms are not acceptable.
  - 1. Form: Processed, plain salt pellets.

## 2.03 WATER TESTING SETS

- A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

## PART 3 - EXECUTION

### 3.01 WATER SOFTENER INSTALLATION

- A. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.
- C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
- D. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.

### 3.02 CONNECTIONS

- A. Refer to Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC" for piping joining materials, joint construction, and basic installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric fittings.
- D. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
- E. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank.
- F. Install valved bypass water piping around water softeners.
- G. Install drains as indirect wastes to spill into open drains or over floor drains.

### 3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

### 3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Add water to brine tanks and fill with salt.
  - 1. Commercial Water Softeners: Plain salt pellets.
- C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics. Comply with the following:
  - 1. ASTM D 859, "Test Method for Silica in Water."
  - 2. ASTM D 1067, "Test Methods for Acidity or Alkalinity of Water."
  - 3. ASTM D 1068, "Test Methods for Iron in Water."
  - 4. ASTM D 1126, "Test Method for Hardness in Water."
  - 5. ASTM D 1129, "Terminology Relating to Water."
  - 6. ASTM D 3370, "Practices for Sampling Water from Closed Conduits."

### 3.05 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water softeners.

END OF SECTION 22 31 00

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## SECTION 223300 - ELECTRIC DOMESTIC WATER HEATERS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Commercial, storage electric water heaters.

#### 1.02 SUBMITTALS

- A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.
- D. Warranty.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

#### 1.04 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures including storage tank and supports.
    - b. Faulty operation of controls.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
  - 2. Warranty Period(s): From date of Substantial Completion:
    - a. Commercial Electric Water Heaters: Three years.

## PART 2 - PRODUCTS

### 2.01 COMMERCIAL ELECTRIC WATER HEATERS

#### A. Commercial, Storage Electric Water Heater; WH-A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Lochinvar Corporation.
  - b. Smith, A. O. Water Products Company.
2. General
  - a. Comply with UL 1453 requirements for storage-tank-type water heaters.
  - b. Capacity: Size, location, capacity, and model as indicated on Drawings.
3. Storage-Tank Construction: Non-ASME-code.
  - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
    - 1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
  - b. Pressure Rating: 150 psig.
  - c. Interior Finish: Glass-lined. Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
4. Factory-Installed Storage-Tank Appurtenances:
  - a. Anode Rod: Replaceable magnesium.
  - b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
  - c. Insulation: Comply with ASHRAE/IESNA 90.1.
  - d. Jacket: Steel with enameled finish.
  - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
    - 1) Staging: Input not exceeding 3 kW per step.
  - f. Temperature Control: Adjustable thermostat.
  - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
  - h. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
5. Special Requirements: NSF 5 construction.

## PART 3 - EXECUTION

### 3.01 WATER HEATER INSTALLATION

- A. Install commercial water heaters on concrete bases.
  - 1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
  - 2. Concrete base construction requirements are specified in Division 20 Section "Common Work Results for Plumbing."
- B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial, water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- D. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
- E. Install thermometer on outlet piping of water heaters. Refer to Division 20 Section "Meters and Gages for Plumbing Piping" for thermometers.
- F. Fill water heaters with water.

### 3.02 CONNECTIONS

- A. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### 3.03 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections.
- B. Perform the following field tests and inspections:
  - 1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

END OF SECTION 22 33 00

## SECTION 224000 – PLUMBING FIXTURES

### PART 1 - GENERAL

#### 1.01 SUMMARY

A. This Section includes the following:

1. Faucets.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Water closets.
7. Urinals.
8. Lavatories.
9. Individual showers.
10. Sinks.
11. Ice maker boxes.
12. Clothes washer boxes.

B. Related Sections include the following:

1. Division 22 Section "Drinking Fountains and Water Coolers."

#### 1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Standard: Comply with the latest adopted version of NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
  - 1. Plastic Shower Enclosures: ANSI Z124.2.
  - 2. Slip-Resistant Bathing Surfaces: ASTM F 462.
  - 3. Stainless-Steel Sinks: ASME A112.19.3.
  - 4. Vitreous-China Fixtures: ASME A112.19.2M.
  - 5. Water-Closet, Flush Valve Trim: ASME A112.19.5.
- G. Comply with the following applicable standards and other requirements specified for lavatory/sink faucets:
  - 1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
  - 2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
  - 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
  - 4. Faucets: ASME A112.18.1.
  - 5. Hose-Connection Vacuum Breakers: ASSE 1011.
  - 6. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
  - 7. NSF Potable-Water Materials: NSF 61.
  - 8. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
- H. Comply with the following applicable standards and other requirements specified for bathtub/shower faucets:
  - 1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
  - 2. Faucets: ASME A112.18.1.
  - 3. Hand-Held Showers: ASSE 1014.
  - 4. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
  - 5. Manual-Control Antiscald Faucets: ASTM F 444.
  - 6. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
  - 1. Atmospheric Vacuum Breakers: ASSE 1001.
  - 2. Brass and Copper Supplies: ASME A112.18.1.
  - 3. Brass Waste Fittings: ASME A112.18.2.
  - 4. Manual-Operation Flushometers: ASSE 1037.
  - 5. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
  - 6. Supply Fittings: ASME A112.18.1.
- J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
  - 1. Flexible Water Connectors: ASME A112.18.6.
  - 2. Grab Bars: ASTM F 446.
  - 3. Hose-Coupling Threads: ASME B1.20.7.
  - 4. Off-Floor Fixture Supports: ASME A112.6.1M.
  - 5. Pipe Threads: ASME B1.20.1.
  - 6. Plastic Toilet Seats: ANSI Z124.5.
  - 7. Supply and Drain Protective Shielding Guards: ICC A117.1.

## PART 2 - PRODUCTS

### 2.01 FLUSH VALVE WATER CLOSETS

#### A. Water Closets; WC-1, 2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard "Afwall FloWise" 2257.001, or a comparable by the following:
  - a. Kohler Co.
  - b. Sloan.
  - c. Zurn Plumbing Products Group.
2. Description: Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
  - a. Style: Flushometer valve.
  - b. Bowl Type: Elongated with siphon-jet design.
  - c. Height: Refer to the plumbing fixture schedule on the Drawings.
  - d. Design Consumption: 1.28 gal./flush.
  - e. Color: White.

### 2.02 WATER CLOSET FLUSHOMETERS

#### A. Water Closet; WC-1, 2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan Solis 8111-1.28, or a comparable by the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Flushometer for water-closet type fixture. Include brass body with corrosion and chlorine resistant internal components, dual-filtered bypass, synthetic rubber diaphragm assembly, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
  - a. Internal Design: Diaphragm operation.
  - b. Style: Exposed.
  - c. Inlet Size: NPS 1.
  - d. Trip Mechanism: Solar powered, infrared sensor actuator, alkaline battery back-up.
  - e. Consumption: 1.28 gal./flush.
  - f. Tailpiece Size: NPS 1-1/2 and standard length to top of bowl.

## 2.03      FIXTURE SUPPORTS

- A.    Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1.    Josam Company.
  - 2.    Smith, Jay R. Mfg. Co.
  - 3.    Zurn Plumbing Products Group; Specification Drainage Operation.
- B.    Water-Closet Supports; WC-1, 2:
  - 1.    Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-less waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
    - a.    Support Rating: Extra heavy duty.
    - b.    Support Loading: 750 pounds.
  - 1)    Base support must be securely anchored to floor with 1/2" anchors able to withstand a pull-out force of 500 pounds. The rear anchor bar must be securely anchored to floor with 1/2" anchors able to withstand a pull-out force of 1000 pounds.

## 2.04      TOILET SEATS

- A.    Toilet Seats; WC-1, 2:
  - 1.    Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a.    Bemis Manufacturing Company.
    - b.    Church Seats.
    - c.    Olsonite Corp.
  - 2.    Description: Toilet seat for water-closet-type fixture.
    - a.    Material: Molded, solid plastic.
    - b.    Configuration: Open front less cover.
    - c.    Size: Elongated.
    - d.    Hinge Type: Stainless steel, self-sustaining check hinge.
    - e.    Class: Extra heavy-duty, commercial.
    - f.    Color: White.

## 2.05 URINALS

### A. Urinals; UR-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard "Washbrook FloWise" 6590.001 or a comparable product by one of the following:
  - a. Kohler Co.
  - b. Sloan.
  - c. Zurn Plumbing Products Group.
2. Description: Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
  - a. Type: Washout.
  - b. Strainer or Trapway: Stainless steel strainer with integral trap.
  - c. Design Consumption: 0.5 gal./flush.
  - d. Color: White.
  - e. Supply Spud Size: NPS 3/4.
  - f. Outlet Size: NPS 2.

## 2.06 URINAL FLUSHOMETERS

### A. Urinal; UR-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan Solis 8186-0.125, or a comparable product by one of the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Flushometer for urinal type fixture. Include brass body with corrosion and chlorine resistant internal components, dual-filtered bypass, synthetic rubber diaphragm assembly, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
  - a. Internal Design: Diaphragm operation.
  - b. Style: Exposed.
  - c. Inlet Size: NPS 3/4.
  - d. Trip Mechanism: Solar powered, infrared-sensor actuator.
  - e. Consumption: 0.125 gal./flush.
  - f. Tailpiece Size: NPS 3/4 and standard length to top of bowl.

## 2.07 FIXTURE SUPPORTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Josam Company.
  - 2. Smith, Jay R. Mfg. Co.
  - 3. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Urinal Supports; UR-1:
  - 1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

## 2.08 LAVATORIES

- A. Lavatories; L-1:
  - 1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard "Ovalyn" 0496.221 or a comparable product by one of the following:
    - a. Kohler Co.
    - b. Sloan.
    - c. Zurn Plumbing Products Group.
  - 2. Description: Under-counter mounting, vitreous-china fixture.
    - a. Size: 19-1/4 by 16-1/4 inches rim, 17 by 16-1/4 inches oval bowl.
    - b. Color: White.
    - c. Finish: Unglazed rim.
  - 3. Subject to compliance with requirements, provide trim products by one of the following:
    - a. McGuire Manufacturing Company.
    - b. Engineered Brass Company.
    - c. Keeney Manufacturing Company.
  - 4. Lavatory Trim
    - a. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
    - b. Drain: Grid with ADA compliant offset waste.
    - c. Drain Piping: NPS 1-1/4 chrome-plated cast-brass P-trap with cleanout; NPS 1-1/4 17 gauge tubular brass waste to wall; and wall escutcheon.

2.09 LAVATORY FAUCETS

A. Lavatory Faucets; L-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Sloan EFX-275.500.0100, or an approved equal:
2. Description: Sensor-control mixing valve. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Polished chrome plate.
  - c. Maximum Flow Rate: 0.5 gpm.
  - d. Centers: Single hole with 4-inch deck plate.
  - e. Mounting: Deck, exposed.
  - f. Inlet(s): NPS 3/8 tubing, with NPS 1/2 male adaptor.
  - g. Spout Outlet: Aerator.
  - h. Power Source: Integral solar panel.
  - i. Temperature Control: Internal mixer.
  - j. Warranty: 3-year limited.

2.010 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers; L-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Truebro 103 E-Z or a comparable product by one of the following:
  - a. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
  - b. Plumberex Specialty Products Inc.
2. Description: Manufactured plastic wraps for covering plumbing fixture hot and cold water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
  - a. Material: Molded vinyl.
  - b. Nominal Thickness: 1/8" constant wall.
  - c. UV Protection: Required.
  - d. Fasteners: Internal, reusable fasteners.
  - e. Color: White.

## 2.011 INDIVIDUAL SHOWERS

### A. Individual Showers; SH-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Aqua Bath C6530TD-FUS-3/4" or a comparable product by one of the following:
  - a. Aqua Glass Corporation.
  - b. Aquatic.
  - c. Praxis Industries, Inc.; Aquarius Products.
2. Description: Accessible, vacuum formed acrylic shower enclosure with slip-resistant bathing surface.
  - a. Size: 60 by 30 by 78 inches interior dimensions.
  - b. Surround: One piece.
  - c. Color: White.
  - d. Accessibility: Include ADA compliant 18 gauge stainless steel grab bars and folding phenolic slat bench with stainless steel trim.
  - e. Drain: Trench drain, NPS 2 outlet, stainless steel strainer.
  - f. Options (furnished by manufacturer):
    - 1) Integrally molded soap dish.
    - 2) Stainless steel curtain rod
    - 3) Weighted anti-microbial shower curtain.

## 2.012 SHOWER FAUCETS

### A. Shower Faucets; SH-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard R120SS (valve), T675.507 (valve trim), 1660.505 (handheld shower), 8888.035 (shower hose), 8888.038 (wall supply bracket), R420 (diverter), T506.430 (diverter trim), or a comparable by the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Single-handle pressure-balance valve with fixed shower head and handheld shower. Coordinate faucet inlets with supplies and outlet with shower heads.
  - a. Body Material: Cast bronze, non-metallic pressure valve assembly, metal handle.
  - b. Finish: Polished chrome plate.
  - c. Maximum Flow Rate: 1.5 gpm (fixed head), 2.5 gpm (handspray)
  - d. Diverter Valve: Not integral with mixing valve.
  - e. Construction: Concealed mount, ceramic disk valve, adjustable hi-limit stop, integral service stops.
  - f. Supply Connections: NPS 1/2, Sweat.
  - g. Shower Head Type: Ball joint and head, 4" arm with escutcheon.
  - h. Shower Head Material: Non-metallic with chrome-plated finish.
  - i. Spray Pattern: Fixed.
  - j. Hand Held Shower Type: Bracket mounted, wall supply, 59" hose.
  - k. Backflow Protection Device for Hand-Held Shower: Required.
  - l. Hand Held Shower Material: Nonmetallic with chrome-plate finish.

## 2.013 KITCHEN SINKS

### A. Kitchenette Sinks; SK-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay LR-2522 or a comparable product by one of the following:
  - a. Just Manufacturing Company.
2. Description: One-bowl, counter-mounting, stainless-steel kitchenette type sink.
  - a. Overall Dimensions: 25 by 22 by 8-1/8 inches.
  - b. Metal Thickness: 18 gauge type 302 (18-8) stainless steel.
  - c. Faucet Hole Punching: Three holes, 4-inch centers.
  - d. Bowl Dimensions: 21 by 15-3/4 by 8-1/8 inches.
  - e. Drain: 3-1/2-inch stainless steel crumb cup; Elkay LK35.
    - 1) Location: Center of bowl.
3. Subject to compliance with requirements, provide trim products by one of the following:
  - a. McGuire Manufacturing Company.
  - b. Keeney Manufacturing Company.
4. Sink Trim
  - a. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
  - b. Drain Piping: NPS 1-1/2 chrome-plated cast-brass P-trap with cleanout; NPS 1-1/2 17 gauge tubular brass waste to wall; and wall escutcheon.

## 2.014 KITCHEN SINK FAUCETS

### A. Kitchenette Sink Faucets; SK-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard 4275.550.F15, or a comparable by the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Kitchen faucet without spray. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Polished chrome plate.
  - c. Maximum Flow Rate: 1.5 gpm.
  - d. Mixing Valve: Two-handle.
  - e. Centers: 8-inch.
  - f. Mounting: Deck, exposed.
  - g. Handle(s): Lever.
  - h. Inlet(s): NPS 1/2 male shank.
  - i. Spout Type: Swing, solid brass.
  - j. Spout Outlet: Aerator.
  - k. Operation: Ceramic, manual.

## 2.015 PAINT SINKS

### A. Paint Sinks; SK-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay WNSF8236LR2, or a comparable by the following:
  - a. Advance Tabco.
  - b. Just Manufacturing.
2. Description: Two-bowl, free-standing, stainless-steel kitchen-type sink.
  - a. Overall Dimensions: 84 by 27-1/2 by 36 inches, 8 inch tall backsplash.
  - b. Metal Thickness: 14 gauge type 304 stainless steel.
  - c. Metal Finish: Buffed satin.
  - d. Bowl Dimensions: 18 by 24 by 14 inches, center drain location.
  - e. Drainboard Dimensions: 24 by 24 inches.
  - f. Drainboard Locations: Left and Right.
  - g. Accessories:
    - 1) Furnish all standard accessories in addition to those herein.
    - 2) Stainless-steel legs with adjustable bullet feet.
    - 3) Elkay LK25RT 2" rotary lever waste.
    - 4) Furnish with two (2) sets of faucet punching centered on each bowl.
3. Sink Trim
  - a. Drain Piping: NPS 2 chrome-plated cast-brass P-trap with cleanout; NPS 2 17-gauge tubular brass waste to wall; wall escutcheon.

## 2.016 PAINT SINK FAUCETS

### A. Paint Sink Faucets; SK-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Chicago 540-LDL9E1ABCP or a comparable by the following:
  - a. T&S Brass.
  - b. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Commercial kitchen faucet. Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Polished chrome plate.
  - c. Mixing Valve: Two-handle.
  - d. Centers: 8 inches.
  - e. Mounting: Wall, exposed.
  - f. Handle(s): Lever.
  - g. Inlet(s): NPS 1/2 female with 2" flanges.
  - h. Spout Type: 9-1/2" swivel gooseneck, full flow outlet, solid brass.
  - i. Operation: Quarter turn, renewable compression, manual.

2.017 CRAFT SINKS

A. Craft Sinks; SK-3:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay DLR-252210 or a comparable product by one of the following:
  - a. Just Manufacturing Company.
2. Description: One-bowl, counter-mounting, stainless-steel deep bowl art sink.
  - a. Overall Dimensions: 25 by 22 by 10-1/8 inches.
  - b. Metal Thickness: 18 gauge type 302 (18-8) stainless steel.
  - c. Faucet Hole Punching: Three holes, 4-inch centers.
  - d. Bowl Dimensions: 21 by 15-3/4 by 10-1/8 inches.
  - e. Drain: 3-1/2-inch grid; Elkay LK18.
    - 1) Location: Centered in bowl.
1. Subject to compliance with requirements, provide trim products by one of the following:
  - a. McGuire Manufacturing Company.
  - b. Keeney Manufacturing Company.
2. Sink Trim
  - a. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
  - b. Plaster Trap: Equal to Jay R. Smith 8710T.

2.018 CRAFT SINK FAUCETS

A. Craft Sink Faucets; SK-3:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Chicago 201-AGN8AE35ABCP or a comparable product by one of the following:
  - a. T & S Brass and Bronze Works, Inc.
  - b. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Manual-control mixing valve with gooseneck spout. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Polished chrome plate.
  - c. Maximum Flow Rate: 1.5 gpm.
  - d. Mixing Valve: Two-handle.
  - e. Centers: 8 inches.
  - f. Mounting: Deck, concealed.
  - g. Handle(s): Lever with color coded index button.
  - h. Inlet(s): NPS 1/2 male shank.
  - i. Spout Type: 8" gooseneck, swing, solid brass.
  - j. Spout Outlet: Aerator.
  - k. Operation: Quarter-turn, renewable compression, manual.

2.019 LAUNDRY TUBS

A. Laundry Tubs; LT-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Fiat L-1 or a comparable product by one of the following:
  - a. Swan.
  - b. Stern-Williams.
2. Description: One-bowl, wall-mounting, molded stone utility tub.
  - a. Overall Dimensions: 23 by 21 by 13-7/16 inches.
  - b. Faucet Hole Punching: Two holes, 4-inch centers.
  - c. Mounting: Wall mounting bracket.
3. Subject to compliance with requirements, provide trim products by one of the following:
  - a. McGuire Manufacturing Company.
  - b. Engineered Brass Company.
  - c. Keeney Manufacturing Company.
4. Sink Trim
  - a. Drain: Chrome plated brass tray plug with rubber stopper and chain.
  - b. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
  - c. Drain Piping: NPS 1-1/2 chrome-plated cast-brass P-trap with cleanout; NPS 1-1/2 17 gauge tubular brass waste to wall; and wall escutcheon(s).

2.020 LAUNDRY TUB FAUCETS

A. Laundry Tub Faucets; LT-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard 2475.540, or a comparable by the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Manual-control mixing valve with double bend spout. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Polished chrome plate.
  - c. Mixing Valve: Two handle.
  - d. Centers: 4 inches.
  - e. Mounting: Deck, exposed.
  - f. Handle(s): Lever.
  - g. Inlet(s): NPS 1/2 male shank.
  - h. Spout Type: Swing, solid brass.
  - i. Spout Outlet: Aerator.
  - j. Operation: Ceramic, manual.

2.021 MOP SINKS

A. Mop Sinks; MS-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Fiat MSB-2424 or a comparable product by one of the following:
  - a. Swan.
  - b. Stern-Williams.
2. Description: One-bowl, floor-mounting, molded stone utility sink.
  - a. Overall Dimensions: 24 by 24 by 10 inches.
  - b. Drain: 3-inch I.P.S. cast brass with 16 gauge stainless steel dome strainer and lint basket.
  - c. Accessories:
    - 1) Hose and Bracket: Stainless steel hose bracket, spring-loaded rubber grip, 30" long heavy duty 5/8-inch rubber hose; Fiat 832 AA.
    - 2) Mop Hanger: Stainless steel mop hanger bracket, 24 by 3 inches, 3-spring loaded rubber grips; Fiat 889 CC.
    - 3) Stainless steel wall guards: Heavy gauge stainless steel, two/three panels as required; Fiat MSG 2424.

2.022 MOP SINK FAUCETS

A. Mop Sink Faucets; MS-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Standard 8344.012.004, or a comparable by the following:
  - a. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Service sink faucet with check stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
  - a. Body Material: Commercial, solid brass.
  - b. Finish: Rough chrome plate.
  - c. Mixing Valve: Two-handle.
  - d. Centers: 8 inches.
  - e. Mounting: Back/wall, exposed.
  - f. Handle(s): Lever.
  - g. Inlet(s): NPS 1/2 male shank, with integral check stops.
  - h. Spout Type: Rigid, solid brass with wall brace and bucket hook.
  - i. Spout Outlet: Hose thread.
  - j. Vacuum Breaker: Integral with spout.
  - k. Operation: Ceramic, manual.

2.023 ICE MAKER BOXES

A. Ice Maker Boxes; IMB-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Guy Gray MIB1HAAB or a comparable product by one of the following:
  - a. Acorn Engineering Company.
  - b. IPS Corporation.
2. Description: Recessed wall-mounting water supply box.
  - a. Overall dimension: 4-3/4 by 4-1/8 by 3-1/2 inches.
  - b. Metal Thickness: 20 gauge cold rolled steel.
  - c. Supplies: 1/2" sweat inlet.
  - d. Valve: Integral hammer arrester quarter turn, 1/4" O.D. outlet.
  - e. Finish: White powder coat.

2.024 CLOTHES WASHER BOXES

A. Washer Boxes; WB-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Guy Gray MWB19 or a comparable product by one of the following:
  - a. Acorn Engineering Company.
  - b. IPS Corporation.
2. Description: Recessed wall-mounting water supply box.
  - a. Overall dimension: 8-1/4 by 5-5/8 by 3-1/2 inches.
  - b. Metal Thickness: 20 gauge cold rolled steel.
  - c. Supplies: 1/2" sweat inlet.
  - d. Valve: Integral hammer arrester quarter turn, 3/4" O.D. outlet.
  - e. Drain: 2" slipnut drain kit.
  - f. Finish: White powder coat.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
  1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

- D. Install fixtures level and plumb according to roughing-in drawings.
- E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
- F. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- G. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- H. Install toilet seats on water closets.
- I. Install traps on fixture outlets.
  - 1. Exception: Omit trap on fixtures with integral traps.
  - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- J. For countertop mounted fixtures, verify fit into casework prior to ordering. Coordinate with millwork fabrication drawings.
- K. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 20 Section "Common Work Materials and Methods for Fire Suppression, Plumbing, and HVAC."
- L. Set showers and mop sinks in leveling bed of cement grout. Grout is specified in Division 20 Section "Common Work Materials and Methods for Fire Suppression, Plumbing, and HVAC."
- M. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

### 3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
- E. Install fresh batteries in sensor-operated mechanisms.

3.04 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00

## SECTION 224700 – DRINKING FOUNTAIN AND WATER COOLERS

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Type PB, pressure with bubbler, Style W, wall-mounting water coolers.
  - 2. Remote chiller.

#### 1.02 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.
- C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- D. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
- E. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants" for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

## PART 2 - PRODUCTS

### 2.01 PRESSURE WATER COOLERS

#### A. Water Coolers; EWC-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Halsey Taylor HTHBWF-OVLSER-I or an approved equal.
2. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler.
  - a. Cabinet: Bi-level modular type with projected round stainless-steel bowls, stainless-steel backsplash, HydroBoost bottle filling station.
  - b. Color: Brushed stainless steel with silver ion anti-microbial.
  - c. Bubbler: One, with adjustable stream regulator, located on each bowl.
  - d. Control: Push pad.
  - e. Filter: One installed water filter complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
  - f. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
    - 1) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.
    - 2) Electrical Characteristics: 1/4 hp; 120-V ac; single phase; 60 Hz.
  - g. HydroBoost Bottle Filling Station
    - 1) Description: Sensor-activated enhanced with user interface graphics.
    - 2) Quick-fill rate: 1.1 gpm with laminar flow.
    - 3) Green counter: Visually displays count of plastic bottles saved from landfills.
3. Options:
  - a. Provide twelve additional filter cartridges (turned over to Owner); Halsey Taylor 55898C\_12PK.
  - b. Cane touch Apron for upper bowl; Halsey Taylor HTOVLAPR.
  - c. Access panel; Halsey Taylor ACCESS12X38-5.
4. Subject to compliance with requirements, provide trim products by one of the following:
  - a. McGuire Manufacturing Company.
  - b. Engineered Brass Company.
  - c. Keeney Manufacturing Company.
5. Water Cooler Trim
  - a. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
  - b. Drain: Grid with NPS 1-1/4 horizontal waste and trap complying with ASME A112.18.1. NPS 1-1/4 chrome-plated cast-brass P-trap with cleanout; NPS 1-1/4 17 gauge tubular brass waste to wall; and wall escutcheon.

B. Water Coolers; EWC-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Halsey Taylor HTHBWF-OVLSEBP-I or an approved equal.
2. Description: Accessible, Style W, wall-mounting drinking fountain.
  - a. Cabinet: Bi-level modular type with projected round stainless-steel bowls, stainless-steel backsplash, HydroBoost bottle filling station.
  - b. Color: Brushed stainless steel with silver ion anti-microbial.
  - c. Bubbler: One, with adjustable stream regulator, located on each bowl.
  - d. Control: Push pad.
  - e. Filter: One installed water filter complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
  - f. HydroBoost Bottle Filling Station
    - 1) Description: Sensor-activated enhanced with user interface graphics.
    - 2) Quick-fill rate: 1.1 gpm with laminar flow.
    - 3) Green counter: Visually displays count of plastic bottles saved from landfills.
3. Options:
  - a. Provide twelve additional filter cartridges (turned over to Owner); Halsey Taylor 55898C\_12PK.
  - b. Cane touch Apron for upper bowl; Halsey Taylor HTOVLAPR.
  - c. Access panel; Halsey Taylor ACCESS12X38-5.
4. Subject to compliance with requirements, provide trim products by one of the following:
  - a. McGuire Manufacturing Company.
  - b. Engineered Brass Company.
  - c. Keeney Manufacturing Company.
5. Water Cooler Trim
  - a. Supplies: Chrome-plated copper with 1/2" NPT x 3/8" OD loose key stops.
  - b. Drain: Grid with NPS 1-1/4 horizontal waste and trap complying with ASME A112.18.1. NPS 1-1/4 chrome-plated cast-brass P-trap with cleanout; NPS 1-1/4 17 gauge tubular brass waste to wall; and wall escutcheon.

2.02 REMOTE CHILLER

A. Remote Chiller for EWC-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Halsey Taylor SJ8 or an approved equal.
2. Description: Above-ceiling mounted remote chiller.
  - a. Cabinet: Heavy gauge galvanized steel.
  - b. Supply: NPS 3/8 inlet with ball, gate, or globe valve, NPS 3/8 outlet.
  - c. Mounting: Furnish with manufacturer supplied shelf support.

- d. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
  - 1) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.
  - 2) Electrical Characteristics: 1/5 hp; 120-V ac; single phase; 60 Hz.

### PART 3 - EXECUTION

#### 3.01 APPLICATIONS

- A. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view.

#### 3.02 INSTALLATION

- A. Install manufacturer furnished wall mounting brackets and affix to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
- B. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 20 Section "Pipe, Valves, Fittings, and Hangers for Fire Suppression, Plumbing, and HVAC."
- D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- E. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."
- F. Turn over spare supply of water filters (for each unit installed) to Owner.

#### 3.03 CONNECTIONS

- A. Connect fixtures with water supplies, traps, and risers, and with soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

- A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
  - 1. Remove and replace malfunctioning units and retest as specified above.
  - 2. Report test results in writing.

3.05 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.

END OF SECTION 22 47 00

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## SECTION 230593 – TESTING AND BALANCING

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Work Specified Elsewhere
  - 1. Control Systems Equipment: Section 23 09 00

#### 1.02 SUMMARY

- A. This Section includes testing, adjusting and balancing of HVAC Systems to produce design objectives, including the following:
  - 1. Adjusting blowers, fans and ducts to deliver or exhaust design air flow.
  - 2. Adjusting terminal units, diffusers, registers and grilles to supply, return or exhaust design air flow.
  - 3. Adjusting relief dampers and vents.
  - 4. Adjusting diffusers, registers and grilles to minimize drafts.
  - 5. Adjusting all zones for design supply and return air flow.
  - 6. Adjusting blowers and fans to design rpm.
  - 7. Balancing of heating water, cooling water, and condenser water systems to achieve design flow characteristics.
  - 8. Balancing of domestic hot water return loop.
  - 9. Adjusting VAV terminal box controllers to design cfm. (Heating and Cooling).
  - 10. Sheet metal shop drawing review prior to ductwork installation, review the Sheet Metal Contractor's duct fabrication drawings and mark any additional balancing dampers, etc. that are required for proper balancing of the systems. This Contractor shall receive two copies from the Sheet Metal Contractor and shall return one copy to Sheet Metal Contractor.

#### 1.03 SUBMITTALS

- A. Bidding Documents
  - 1. If so requested on the bid form Submit name of the Test and Balance Agency to Architect/Engineer as a subcontractor on the Materials and Subcontractors Listing.
  - 2. If the Contractor fails to submit name of selected Test and Balance Agency, the Architect/Engineer will select the agency of his choice and Contractor must then issue purchase order for this work as directed.
- B. Certificate: Selected and approved agency shall submit certificate immediately upon receipt of test and balance contract.

C. Data Sheets

1. Submit type written data sheets on each item of testing equipment to be used.
2. Include name of device, manufacturer's name, model number, latest date of calibration and correction factors.

D. Report Forms

1. Submit specimen copies of the balance report set-up including addendums and alternates before starting work on site.
2. Submit 30, 60, 90 percent site visit reports on installation of HVAC systems.
3. Forms shall be 8-1/2" x 11" paper for loose-leaf binding, with blanks for listing of the required test ratings and for certification of report.
4. Submit preliminary pencil copies of reports as A/E determines.

E. Final Report

1. Upon completion, all information shall be neatly typed and five copies submitted to the Architect/Engineer with accompanying schematic diagrams of systems tested.
2. All test reports shall be assembled, indexed and submitted in vinyl covered loose-leaf notebooks with project name and Balancing Contractor's name permanently printed thereon.

1.04 QUALITY ASSURANCE

A. Test and Balance Agency

1. Obtain the services of an independent Test and Balance Agency that specializes in, and whose business is limited to, the testing and balancing of air conditioning systems.
2. The agency selected shall be fully certified by the NEBB and shall have at least one member of the agency qualified as a certified test and balance Engineer who has been issued this certification by the National Examining Board.
3. All work shall be done under the direct supervision of a full time member of the organization.
4. All final reports shall be signed and sealed by the certified test and balance Engineer.
5. Approved Test and Balance Contractors:
  - a. Mechanical Systems Balancing
  - b. Total Balance
  - c. Fluid Dynamics
  - d. Gibson Services.
  - e. Midwest Balance
  - f. Synergy Test and Balance
  - g. Bledsoe Test and Balance
6. Agency Contract: Award the contract to the approved Balance Contractor in sufficient time to allow the Test and Balance Contractor to schedule this work in cooperation with other trades involved and comply with the completion date.

B. Instruments

1. The minimum instrumentation for testing, adjusting and balancing shall be the "NEBB Approved Minimum Field Instrumentation."

2. Instruments used for testing and balancing must have been calibrated within a period of six months and checked for accuracy prior to start of work.
  3. Instruments must be maintained and carried in such manner to protect them from excessive vibration and moisture conditions.
  4. Approval: all products and instrumentation used shall be subject to approval of the Engineer.
- C. Procedure - Methodology: testing and balancing shall be performed in complete accordance with NEBB National Standards for Field Measurements and Instrumentation.
- D. Conditions: System Operation - heating, ventilating, and air conditioning equipment including filters, shall be completely installed and in continuous operation as required to accomplish the adjusting and balance work specified. Test and Balance Agency shall give a Check List to the Mechanical and/or Sheet Metal Contractors which, when completed, and returned, will assure the systems are ready to be balanced. A/E shall receive a copy of check list from Mechanical and Sheet Metal Contractors when completed.

#### 1.05 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, Commissioning Agent (if applicable) and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.
- B. Notice: Provide seven (7) days advance notice for each test. Include scheduled test date and times.
- C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
- D. Measurements – Readjustments
1. Should corrective measures caused by faulty installation require retesting, adjusting and balancing, such work shall be at no additional expense.
  2. Corrective measures other than the above shall be made only as directed by the Architect/Engineer. Such work shall be at no additional expense.

#### PART 2 - PRODUCTS (NOT APPLICABLE)

#### PART 3 - EXECUTION

##### 3.01 PREPARATION

- A. Air Systems - prior to system testing and balancing
1. Verify that the appropriate contractor has:
    - a. Checked all systems and placed them into a fully operational status.
    - b. Cleaned all air filters or installed new ones as required.
    - c. Checked temperature and system controls for proper operation.

- d. Checked fan rotation for proper operation.

B. Water Systems - prior to system testing and balancing

1. A complete air balance must be accomplished before beginning the water system test and balance.
2. Open all valves to full open position. Close coil bypass stop valves. Set mixing valves to full coil flow.
3. Set all temperature controls so all coils are calling for full cooling or full heating as required.
4. Verify that the Mechanical Contractor has:
  - a. Removed and cleaned all strainers.
  - b. Treated and cleaned water in system.
  - c. Checked pump rotation.
  - d. Set automatic fill valves for required system pressure.
  - e. Bled the system, checked the expansion tanks, etc., so that it is completely full of water and is not air bound.
  - f. Check air vents at high points of the system for proper operation.
  - g. Checked automatic bypass valve for proper operation (if required).
  - h. Set operating temperatures of chillers and boilers to design requirements.

3.02 SYSTEM BALANCE

A. Air Systems - Perform the following minimum tests and balance:

1. Test and adjust supply, return and exhaust fans to design requirements. Change sheaves and belts as required to obtain design air quantities. Sheaves and belts to be furnished by respective equipment manufacturer. Sheaves shall be sized so that maximum CFM will be obtained with VFD at 100% speed. Slowing VFD is not an acceptable method to obtain maximum CFM.
2. Test and record motor electrical characteristics, RPM, service factor, measured voltage, full load amperes and connected load amperage. Check and record starter heaters, sizes and ratings, replacing belts sizes, etc.
3. Make pitot tube traverse (minimum of 16 points) of main supply ducts and obtain design CFM at fans. Seal all test holes with suitable hole plugs.
4. Test and record system static pressure, suction and discharge.
5. Test and adjust system for design CFM recirculated air.
6. Test and adjust system for design CFM outside air.
7. Adjust all main supply and return air ducts to proper design CFM.
8. Adjust all zones to proper design CFM, supply and return.
9. Test and adjust each diffuser, grille and register to within  $\pm 10\%$  of design requirements.
10. Each grille, diffuser and register shall be identified as to location and area. Size, type, flow factor and manufacturer of diffusers, grilles, registers and all tested equipment shall be identified and listed.
11. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.
12. The Balance Contractor shall list all controls requiring adjustment by Temperature Control Contractor and assist Control Contractor with required settings.
13. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.
14. Read and adjust the minimum and maximum settings on all variable air volume (VAV) boxes.

B. Water Systems - Perform the following minimum water system test and balance:.

1. Set water pumps to proper gallons per minute delivery  $\pm 10\%$ .
2. Adjust water flow through equipment.
3. Check leaving water temperatures and return water temperatures. Reset to correct design conditions.
4. Check water temperatures at inlet side of coils. Note rise or drop of temperatures from source.
5. Proceed to balance each water coil.
6. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
7. After adjustments to coils are made, recheck settings at the pumps and readjust if required.
8. Install pressure gauges in gauge fittings provided on coil, read pressure drop through coil at set flow rate for full cooling and on full heating. Set pressure drop across bypass valve to match coil full flow pressure drop.
9. Install zone balance valve and size the control valve to the coil it serves.

C. Record Data

1. Air Systems - record the following minimum data:
  - a. CFM delivery and RPM of blowers and fans
    - 1) Static pressure at inlet and outlet of blowers and fans
    - 2) All equipment nameplate data
    - 3) Actual running current and voltage of fan motors and settings for solid state overload relays or heater sizes.
  - b. CFM delivered or exhausted at each diffuser, register, or grille.
2. Water Systems - record the following minimum data at each heating and cooling element:
  - a. Inlet water temperature
  - b. Leaving water temperature
  - c. Pressure drop across each coil
  - d. Pressure drop across bypass valve
  - e. Pump operating suction and discharge pressures and final TDH
  - f. Pump nameplate data
  - g. List all mechanical specifications of pumps. Check and record starter size, heater sizes, etc.
  - h. Rated and actual running amperage of pump motor.
  - i. Water balance device readings and/or settings.

D. Equipment Cards

1. Install at each piece of equipment a "check out" card showing all significant operating temperatures, pressures, amperes, voltages, brake horsepower, etc. Check out cards shall be standard 5" x 8" index cards enclosed in vinyl card folders securely attached to equipment or wall in immediate area.

E. Owner's Instructions: Balancing Contractor shall arrange with the Owner at a time for the instruction of the Owner's personnel as to the proper operation and maintenance of the equipment.

3.03      ADDITIONAL TEST

- A.      Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
  
- B.      Seasonal Periods
  - 1.      If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions, if so requested by Owner/Engineer.

END OF SECTION 23 05 93

## SECTION 230900 – INSTRUMENTATION AND CONTROL FOR HVAC

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 20 00 10 Common Work Results for Fire Suppression, Plumbing and HVAC
- C. Section 20 00 50 Common Materials and Methods for Fire Suppression, Plumbing and HVAC
- D. Sequences of Operation

#### 1.02 SCOPE OF WORK

- A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) with electronic actuation for energy management, equipment monitoring and control, and subsystems as herein specified. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.
- B. Main graphics screen shall allow user to set alarms as off/on/auto.
- C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years.
- D. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes. Control wiring network throughout building shall be completely independent of all other communication/technology systems.
- E. BAS manufacturer shall furnish and/or install all integrated equipment and systems specified herein.
- F. The BAS shall be totally integrated with the existing facility infrastructure systems with user access to all system data locally over a secure Intranet within the building and by remote access by a standard Web Browser over the Internet.
- G. Include HVAC control, electrical, steam, and chilled water metering, energy management, alarm monitoring, and all trending, reporting and maintenance management functions related to normal building operations all as indicated on the drawings or elsewhere in this specification.
- H. The Input/Output Summary Table on the Drawings identifies the minimum points that are to be addressed and incorporated into the Direct Digital Control (DDC) System. Any other points required to accomplish the sequences of operation specified or allow for proper operation of the

equipment shall be provided at no additional cost to the Owner. The Temperature Control Contractor shall fully coordinate all necessary controls interface requirements with the Mechanical Contractor and applicable equipment prior to submittals.

- I. All work performed under this Section of the Specifications shall comply with all codes, laws and governing bodies, and all direct digital controllers and BAS equipment installed shall be U.L. 916 approved.
- J. The system shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air conditioning.
- K. The unitary controllers, intelligent sensors and intelligent actuators shall be based upon BACnet functional profile configurations.
- L. Furnish and install control panels.
- M. Furnish and install all control wiring that is a part of this contract.
- N. Furnish all motorized temperature control dampers, valves and actuators.
- O. Furnish and install all interlocking wiring between mechanical and electrical system components as herein specified including wiring of cooling tower vibration cutout switches.
- P. Furnish and install all 120 volt, 24 volt, communication wiring, data wiring, conduit and accessories to all control panels, actuators, control devices that are part of the Temperature Control System. This includes control wiring associated with chillers, and air cooled condensing units, when applicable.
- Q. Furnish and install Digital Energy Monitors, gas meters, and water meters where shown on Drawings or specified.
- R. Division 26 Contractor shall provide structures and mount all VFD's. Power wiring to VFD's by Electrical Contractor. Power wiring from VFD's to motors by Electrical Contractor. Control wiring to VFD's by Temperature Control Contractor.
- S. Remove all existing pneumatic and electric/electronic controls within the building including compressors, control panels, piping and wiring.
- T. This system shall reside on the Owner's Wide Area Network (WAN) through an Ethernet connection.
- U. Provide DDC interface to all central equipment equipped with BACnet interface. Reference equipment specifications. Provide monitoring and control of equipment (included but not limited to alarm management, water temperatures, component status, etc.)
- V. This system shall be accessible via the Internet without the purchase of any additional hardware or software by the owner. Final connection to the internet shall be by the owner's IT department.
- W. The DDC system shall make only one connection to the owner's LAN in this facility. Any LAN needed between proposed supervisory panels proposed for this system shall run in parallel to the owner's LAN and shall be completely installed and maintained by the TCC. This single connection to the owner's LAN shall be made in the building's IT room.

### 1.03 WORK BY OTHERS

- A. Sheet Metal Contractor will install all control dampers provided by Temperature Control Contractor. Temperature Control Contractor to verify size and location.
- B. Mechanical Contractor will install all taps, control valves and thermo wells in piping for all temperature sensors, flow switches, pressure sensors and any other control device installed in piping.
- C. Mechanical Contractor shall fully coordinate controls interface to all mechanical equipment, with Temperature Control Contractor, prior to ordering equipment to meet intent of sequences of operations.
- D. Mechanical Contractor will install all differential pressure switches including isolation valves.
- E. Mechanical Contractor shall install water meter furnished by Temperature Control Contractor.
- F. Electrical Contractor provides:
  - 1. Wiring of all power feeds through all disconnects, starters and VFD's to electrical motors.
  - 2. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BAS manufacturer.
  - 3. Electrical Contractor will install and connect power wiring to variable frequency drives.
  - 4. Electrical Contractor furnish and install smoke detectors and wire to fan starters.
- G. Terminal unit manufacturer shall install DDC controller, 24V transformer and actuator provided by BAS manufacturer. Power relay for control of VAV boxes shall be provided by terminal unit manufacturer.

### 1.04 QUALITY ASSURANCE

- A. The BAS system shall be designed, installed, commissioned, and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 150 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.
- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- C. BAS shall comply with UL 916 PAZX and 864 UDTZ, European Community, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.
- D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- E. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

- F. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels and extend new field panels on a previously installed network.

#### 1.05 SUBMITTALS

- A. Quantities prepared and submitted as noted in Section 20 00 10 "Shop Drawings".
- B. Submit documentation in the following phased delivery schedule:
  - 1. Valve and damper schedules.
  - 2. Equipment data cut sheets.
  - 3. System schematics, including:
    - a. Sequence of operations
    - b. Point names
    - c. Point addresses
    - d. Interface wiring diagrams
    - e. Panel layouts
    - f. System riser diagrams
    - g. AutoCAD compatible as-built drawings
- C. Upon project completion, submit operation and maintenance manuals, consisting of the following:
  - 1. Index sheet, listing contents in alphabetical order.
  - 2. Manufacturer's equipment parts list of all functional components of the system, AutoCAD disk of system schematics, including wiring diagrams.
  - 3. Description of sequence of operations.
  - 4. As-Built interconnection wiring diagrams.
  - 5. Operator's Manual.
  - 6. Trunk cable schematic showing remote electronic panel locations, and all trunk data.
  - 7. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.).
  - 8. Conduit routing diagrams.
  - 9. One set of software on DVD or USB thumb drive.

#### 1.06 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after substantial completion of entire project.
- B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment, all sensors, and control devices.

## PART 2 - PRODUCTS

### 2.01 Approved BUILDING LEVEL CONTROLLER Manufacturers/Contractors

- A. Johnson Controls - Installation by branch office.

### 2.02 NETWORKING COMMUNICATIONS

- A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers with Application Specific Controllers (ASCs). The multiple networks shall be totally transparent to the user when accessing data or developing control programs.
- B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.

### 2.03 DDC CONTROLLER

- A. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the point I/O schedule listed in the sequence of operation. Each controller shall support a minimum of three (3) Floor Level LAN Device Networks.
- B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:
  - 1. Control processes.
  - 2. Energy management applications.
  - 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
  - 4. Historical/trend data for points specified.
  - 5. Maintenance support applications.
  - 6. Custom processes.
  - 7. Operator I/O.
  - 8. Manual override monitoring.
- C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
- D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- E. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

- F. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- G. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- H. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
  - 1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
  - 2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.

#### 2.04 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

- A. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
- B. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
  - 1. Two-position control.
  - 2. Proportional control.
  - 3. Proportional plus integral control.
  - 4. Proportional, integral, plus derivative control.
  - 5. Automatic tuning of control loops.
- C. DDC Controllers shall have the ability to perform any or all the following energy management routines:
  - 1. Time-of-day scheduling.
  - 2. Calendar-based scheduling.
  - 3. Holiday scheduling.
  - 4. Temporary schedule overrides.
  - 5. Start-Stop Time Optimization.
  - 6. Automatic Daylight Savings Time Switchover.
  - 7. Night setback control.
  - 8. Temperature-compensated duty cycling.
- D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
  - 1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.

2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
  3. DDC Controller software shall provide a HELP function key.
  4. DDC Controller programming shall be capable of comment lines for sequence of operation explanation.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
  2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
  3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hour's destinations) or based on priority.
  4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
  5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data. All trend data shall be available for use in 3rd party personal computer applications (i.e. Microsoft Excel, Lotus 123).
- G. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from an operator workstation, or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
- H. DDC Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points.
- I. The peer to peer network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers

on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple workstation without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

- J. The peer to peer network shall allow the DDC controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

## 2.05 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level local area networks.
- B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum.
  - 1. Central System Controllers
  - 2. Terminal Equipment Controllers
- C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
  - 1. Central System Controllers
  - 2. Provide for control of central HVAC systems and equipment including, but not limited to, the following:
    - a. Air Handling Units
    - b. Built-up Air Handling Systems
    - c. Chilled and Condenser Water Systems
    - d. Heating Water Systems
    - e. Steam Systems
  - 3. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden.
  - 4. Each controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.
  - 5. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing factory programmed or library programs shall not be acceptable. If field-customized Central System controllers cannot be provided,

provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.

6. Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide an DDC Controller to meet the specified functionality.
7. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs.
8. As required by the sequence of operation, provide a door-mounted interface terminal to allow for direct-user access to the controller. Should the Central System controller be unable to interface to a door-mounted terminal, provide a laptop or similar terminal at the controller, or provide a DDC Controller with a door-mounted or local terminal in order to meet the specified minimum functionality. The terminal shall provide the user with the following functionality as a minimum.
  - a. View and set date and time
  - b. Modify and override time-of-day schedules
  - c. View points and alarms
  - d. Monitor points
  - e. Command and modify setpoints

D. Terminal Equipment Controllers

1. Provide for control of each piece of equipment , including, but not limited to, the following:
  - a. Variable Air Volume (VAV) boxes
  - b. Fan Coils
2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard 24V floating control allowing for interface to a variety of modulating actuators. Terminal controllers utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide DDC Controllers or other ASCs with industry standard outputs for control of all terminal equipment.
3. Setpoint adjustment of terminal equipment controllers via space sensors may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at the central workstation, DDC controller, or POT.
4. Each terminal equipment controller shall perform it's primary control function independent of other DDC controller LAN communication or if LAN communication is interrupted. The controller shall receive its real-time data from the DDC Controller time clock. Each controller shall include algorithms that incorporate PID control. Gains for PID control shall be adjustable via POT or operator workstation.

2.06 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30 character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 peer-to-peer Building Level Networks and share

data between any of the 4 networks. The software shall provide, as a minimum, the following functionality.

- a. Real-time graphical viewing and control of environment.
  - b. Scheduling and override of building operations.
  - c. Collection and analysis of historical data.
  - d. Definition and construction of dynamic color graphic displays.
  - e. Editing, programming, storage and downloading of controller databases.
  - f. Alarm reporting, routing, messaging, and acknowledgment.
  - g. Display of dynamic trend data plot.
2. Provide a graphical user interface which shall minimize the use of the keyboard through the use of a mouse or similar pointing device and a "point and click" approach to menu selection. There shall be a minimum of 8 pre-defined function keys to allow quick access to frequently used applications.
3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run within a 32 bit operating system such as Windows NT. These Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.
  - a. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows.
    - 1) Dynamic color graphics and graphic control
    - 2) Alarm management, routing to designated locations, and customized messages
    - 3) Week at a Glance Time-of-day scheduling
    - 4) Trend data definition and presentation
    - 5) Graphic definition and construction
    - 6) Program and point database editing on-line
  - b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.
  - c. Report and alarm printing shall be accomplished via Windows program manager, allowing use of network printers.
4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation that they log onto. A minimum of 200 passwords shall be supported.
5. Operator Activity Tracking - An audit trail report to track system changes, accounting for operator initiated actions, changes made by a particular person or changes made to a specific piece of equipment over a designated time frame shall be printable and archived for future use. The operator activity tracking shall be in a tamperproof buffer file.
6. Reports shall be generated on demand or via pre-defined schedule and directed to either LCD monitors, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
  - a. A general listing of all or selected points in the network
  - b. List of all points currently in alarm

- c. List of all points currently in override status
  - d. List of all disabled points
  - e. List of all points currently locked out
  - f. List of user accounts and access levels
  - g. List all weekly schedules
  - h. List of holiday programming
  - i. List of limits and deadbands
  - j. Excel reports
  - k. System diagnostic reports including a list of DDC panels on line and communicating and status of all DDC terminal unit device points
  - l. List of programs
7. Scheduling and override shall be accomplished via a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in both the PC workstation and DDC Controller to ensure time equipment scheduling when PC is off-line. The PC shall not be required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:
- a. Weekly schedules
  - b. Zone schedules, minimum of 200 unique zones
  - c. Monthly calendars, up to 365 days in advance
8. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
- a. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. BAS contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. BAS contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.
  - b. Provide additional functionality that allows the user to view real-time trend data on trend graph displays. A minimum of six points may be graphed, regardless of whether they have been predefined for trending. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed.

**B. Dynamic Color Graphic Displays**

- 1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, hot water boiler systems, and zone controls shall be provided by the BAS contractor as indicated in the sequence of operation of this specification to optimize system performance analysis and speed alarm recognition.

2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or Bitmap drawings for use in the system.
3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
4. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
5. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
6. Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.
7. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
8. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
9. Off the shelf graphic shall be provided to allow the user to add, modify or delete system graphic displays.
10. A clipart library of HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.
11. A dynamic display of the site specific architecture showing the status of all controllers, operator workstations, and networks shall be provided.

C. System Configuration & Definition

1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
2. Provide automatic backup and restore of all DDC controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
3. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back-up must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

D. Alarm Management

1. Alarm Routing shall allow the user to send alarm notification to selected printers or PC locations based on time of day, alarm severity, or point type.
2. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BAS alarm display screen shall be displayed when the user clicks on the alarm icon.
3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message.

4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.
5. Workstation Communications - Provide automatic communications for buildings as specified in the sequence of operation or as requested by Owner.

## 2.07 FIELD DEVICES

### A. Room Thermostats and Sensors

1. Unless otherwise noted and except for DDC Terminal Unit Controllers sensors, thermostats and temperature sensors located in conditioned spaces shall have locking covers which incorporate a thermometer. Room sensors for DDC Terminal Unit Controllers shall have exposed adjustment with locking-type covers. Thermostats shall be Underwriters Laboratories listed under UL934 for use in air plenum applications. Finish shall be manufacturers standard. All thermostat locations shall be submitted for approval before installation. Unless otherwise indicated or specified, provide one thermostat for each zone shown on the drawings. All thermostat temperature ranges to comply with Section 503.8 "Controls" of the Indiana Energy Code.
  - a. Protective cover provided on room temperature sensors to prevent accidental damage.
  - b. Space temperature sensor covers: durable, impact resistant material finished in acceptable color or acceptable metallic finish matching building hardware: utilize locking type cover screws and have thermometers.
2. Room thermostats and sensors shall be capable of being replaced without the need for controller re-calibration. Room thermostats and sensors shall accordingly have manufactured space temperature and setpoint signal precision tolerances of no greater than 1.0°F. DDC/BAS shall be able to limit space sensor integral adjustment through software commands.
3. Each room thermostat or sensor shall have an integral momentary push button, which can be depressed by the occupant during unoccupied mode of operation. This push button shall cause the DDC controller to bring the unitary air handler or building zone to occupied setpoints for a period of up to 2 hours (adjustable through BAS). Override operation shall be reported to appropriate DDC/BAS operator's terminal to allow generation of custom reports.
4. Electric Thermostats: incorporate bimetal sensing elements and snap-acting contacts rated for the intended service to meet the intent of the control sequences as specified in this section.
5. Provide "flat plate" temperature sensors in all "public areas" (i.e. restrooms, gymnasiums, cafeterias, corridors, etc.) and where indicated on drawings.

### B. Analog Input Sensors

1. Analog sensing devices shall be available for the measurement of common variables such as temperature, static pressure, differential pressure, humidity, fluid flow, etc. All devices shall be standard manufactured for the purpose intended with an output range as specified. High impedance resistive temperature elements shall not be acceptable to reduce transient noise and voltage coupling and damage at the DDC controller.
2. All temperature measuring sensors shall have the capability of providing local indication at the sensing location and specifically at those locations shown on the point chart.

3. Duct temperature sensors shall incorporate a Thermistor bead embedded at the tip of a staticless steel tube. Probe style sensors shall be used in all air handling and duct applications. No averaging sensors allowed.
4. Duct mounted sensors mount through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A seal shall be used on the sensor assembly to prevent air leaks.
5. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250°F and 300 series stainless steel for all other applications.
  - a. Sensor and well shall be supplied as a complete assembly including well head. A thermal conductive compound shall be used in the sensor / well assembly.
  - b. All thermal wells and sensors shall be mounted to allow easy access to sensor for repair or replacement. All thermal wells are to be installed by the Mechanical Contractor.
6. When thermowells are required, sensor and well shall be supplied as a complete assembly including well head. Thermal conductive compound shall be used in sensor/well assembly.
7. Thermowells constructed as to be compatible with the medium being measured.
8. All thermowells and sensors mounted to all easy access to the sensor for repair or replacement; installed as part of the piping work.
9. Outside air sensors designed to withstand the environmental conditions to which they will be exposed; equipped with solar shields.
10. Accuracies: as follows, including errors associated with sensor, leadwire and A to D converter.
  - a. Point Type Accuracy
  - b. Outside Air Temperature 1.0°F
  - c. Chilled Water Temperature 1.0°F
  - d. Space Temperature 1.5°F
  - e. Hot Water Temperature 2.0°F
  - f. Duct Temperature 1.0°F
  - g. Sensors Used in Calibrations 0.5°F

C. Pressure Sensors and Transmitters

1. Pressure sensor construction compatible with the medium being measured.
2. All pressure sensors sized to withstand two times (2x) the average without damage and to hold calibrated accuracy when subject to a momentary forty percent (40%) overrange input.
3. Pressure measurement accuracy within one percent (1%) of the span over an ambient operating temperature of 30°F to 140°F.
4. Differential pressure sensors and transmitters used for flow measurement: sized to the flow sensing device and be supplied with the proper shutoff and bleed valves as required.

D. Humidity Sensors

1. Relative humidity sensors with sensing element rated for the relative humidity range designed into the building environment control system; have an overall accuracy of  $\pm 5\%$  over the range of 30% to 80% RH.
2. Humidity sensors shall be Vaisala 60/70 Series.

E. Differential Pressure Switches

1. Pressure differential switches incorporate corrosion resistance, sensing elements of bourdon tube, bellows or diaphragm type, have tamper-proof adjustable range and differential pressure settings; operate automatically and reset automatically when conditions return to normal.
2. Pressure sensor switch contacts: snap action type.
3. Complete Sensor Assembly protected against vibration at all critical movement pivots, etc.

F. Air Flow Measuring

1. Furnish for installation, by Sheet Metal contractor, AFMS as shown on the drawings.
2. All remote panels and wiring shall be installed by Temperature Control Contractor.
3. Sensor shall be thermal, temperature compensated, 316 stainless steel thermistor probe with 304 stainless steel enclosure.
  - a. Temperature -20 to 160°F
  - b. Humidity 0 to 99% RH
4. Sensor Accuracy
  - a. Greater than 500 FPM, +/- 2%
  - b. Less than 500 FPM, +/- 10 FPM
  - c. Maximum 0.005" w.g. duct probe array pressure drop at 2000FPM
  - d. Electronics output to BAS
5. Manufacturers:
  - a. Ebtron "STx"
  - b. Ruskin Equal

G. Relays

1. Control relays rated for the application, equipped with Form C contacts, in a dustproof enclosure.
2. Relay contacts: silver cadmium with a minimum life span rating of one (1) million operations. Contacts shall be sized appropriately for intended use and amperage.
3. Relay coils equipped with coil transient suppression.
4. All interface relays must be of two piece construction consisting of a plug in relay and a base. Single piece relays commonly known as 'relay in a box' (RIBs) are not acceptable. Maintenance personnel shall be able to change out the relay by plugging a new relay in the base. Relays requiring breaking of wiring connections for maintenance purposes are not permitted.

H. Wire and Cable

1. General: provide all wire and cable required for this installation including connection to existing system.
2. Control wiring:
  - a. Control wiring for Digital Functions: 18 AWG minimum with 600 volt insulation.
  - b. Control wiring for Analog Functions: 18 AWG minimum with 600 volt insulation, shielded 2 or 3 wire to match analog function hardware.
  - c. Control wire and cable shall be run in continuous lengths from control point to control point with no splices allowed.

- d. All control wiring and cable shall be plenum rated.
- e. All control wiring and cable shall be color coded "purple".

I. Field Equipment Panels

- 1. Panels shall be pre-wired and piped and house all controls, transducers, transformers, relays, switches, etc., to coordinate BAS components to achieve specified Direct Digital Control (DDC) sequences.
- 2. Provide NEMA 1 type enclosures, factory fabricated steel or aluminum totally enclosed and equipped with a hinged front door having locking latch. All cabinet locks shall be keyed alike. BAS contractor shall furnish required number of field equipment panels, located adjacent to DDC controllers as necessary to accommodate all panel mounted field equipment.

J. Temperature Control Valves

1. Ball Valves

- a. Fully proportional with cast bronze or cast iron bodies rated for 150 psig. Inner valve to be modulating plug or V-port. Seats shall be changeable bronze.
- b. Water valves shall be sized by the temperature controls manufacturer to produce the required capacity at or equal to a pressure loss of not more than 5 psi. Nominal body rating shall not be less than 150 psig. However, the valve body and packing selected shall be designed and rated for the maximum system operating pressure and temperature at the point of installation. Each valve shall be equipped with proper packing to assure that there will be no leakage at the valve stem.
- c. All 2-way valves shall be single seated valves and have close off ratings greater than the maximum upstream system pressure encountered.
- d. Three-way modulating valves shall have close off ratings equal to or greater than the maximum pressure difference, at any load condition, between the outlet and either of the two outlets for diverting valves.
- e. All valves shall be provided with characterizing disk to improve valve control stability.
- f. All valves shall have blowout proof stem with thrust-bearing double o-ring design. Stem packing gland screw shall be adjustable for wear.
- g. Non corroding chromium plated brass ball or where specified, stainless steel ball and stem, shall be rated at a minimum of 600 PSI WOG (water-oil-gas), cold, non-shock service, and 150 PSI for saturated steam service. All valves shall be provided with reinforced Teflon seats.
- h. Standard chromium plated bronze ball or where specified, stainless steel ball and stem, shall be rated at a minimum of 600 PSI WOG (water-oil-gas), cold, non-shock service, and 150 PSI for saturated steam service. All valves shall be provided with reinforced Teflon seats.
- i. All control valves and actuators shall have a three year full parts and labor warranty.

2. Manufacturers:

- a. Belimo B200 Series with characterizing disc.
- b. Approved Equal

K. Damper and Valve Actuators

- 1. Actuators shall be direct coupled, brushless DC motor type, which require no crank arm and linkage. The actuator shall provide 0 - 10VDC, 0-2-V phased cut or 4 - 20 mA proportional control or two position control or pulse width modulation or Tri-State control

as dictated by HVAC application and sequences of operation. Actuators shall be designed for either clockwise or counterclockwise fail-safe operation, have a manual positioning mechanism and control direction of rotation switch. Run time shall be constant and independent of torque. A 2 to 10VDC feedback signal shall be provided for position feedback or master-slave applications.

2. Actuators shall be UL listed and CSA certified, protected from overload at all angles of rotation and manufactured under ISO 9001 quality control standards.
3. All actuators on fresh air, return air and face and bypass dampers and valves shall be spring return to their normally open or closed position in the event of power failure.
4. Damper actuators: to be mounted outside the airstream and be able to be removed without taking damper apart. Extension shafts to be installed to mount actuators on outside of CSAC units.
5. All actuators shall be electric or electronic and designed to interface with the Direct Digital Control System.
6. Actuator to be designed to close-off against 200% of system operating pressure.
7. All valve actuators on 6" valves and larger shall have external handwheel.
8. Manufacturers:
  - a. Belimo
  - b. Johnson Controls
  - c. Approved equal

L. Low Temperature Detection Thermostats (Freeze Stat)

1. Low temperature detection thermostats: Automatic reset, line voltage, with flexible sensing elements 20 feet long, responsive to lower temperature along entire length. Furnish two (2) thermostats wired in series, each set at 45°F (adjustable) with sensing elements laced across coil discharge.
2. Install in air handling systems where the possibility of freeze-up or freeze-damage of equipment and property exists.

M. Current Sensing Relays

1. Sensing relay shall be a solid state electronic device with split-core design to eliminate the need to remove power conductor for installation or servicing.
2. Amperage rating of 0-135 Amps.
3. Trip set point shall be adjustable to +/- 1% of range. Provide a trip LED. Provide trip set calibration on all current sensors.
4. Sensor supply current is induced from monitored conductor. Minimum conductor current required is 2 Amps. Provide a power LED to indicate that power is available at the current sensing relay.
5. Sensor shall have 600 VAC ms isolation.
6. Current sensor shall be Veris Hawkeye Model H722.

N. Air Differential Pressure Switches

1. Shall be differential pressure type with adjustable range from .05 to 1.0 inches water gauge. Contacts shall be snap acting SPDT and rated for 10 Amps (non-inductive) 120 VAC.

O. Air Static Pressure Transmitter

1. Transmitter shall have range of 0-1@ or 0.5@ WG and send a 4-20milliamp output signal. Zero set range and span set range +/- 5% of full range output. A combined static error (non-linearity, non-repeatability, and hysteresis) +/- 5% of full range output.

P. Variable Frequency Drives (VFD)

1. Provided by Division 26. Interface and control by Division 23.

Q. Smoke Detectors

1. Furnished and installed by Division 26 Contractor. TCC shall supervise detector installation locations and wire into fan circuits; arranged to stop unit fan(s) upon alarm activation.
2. Manufactures:
  - a. General Analysis Corporation
  - b. MSA

R. IAQ (CO<sub>2</sub>) Sensor

1. Measures CO<sub>2</sub> level only - 0 - 2,000 PPM  $\pm$  5% accuracy.
2. Temperature range of 25 degrees F to 130 degrees F.
3. Duct mounted for large spaces where one AHU serves one zone.
4. Room mounted where one AHU serves multiple zones.
5. CO<sub>2</sub> sensors to be self-calibrating and be provided with portable hand held CO<sub>2</sub> and temperature sensor with data logging capability. Telaire 7000SK.
6. Complete with calibration kit.
7. Manufacturers:
  - a. Telaire
  - b. Valtronics Model 6289D
  - c. MSA

S. Outside Air CO<sub>2</sub> Sensor

1. Confirm outside air levels of CO<sub>2</sub> using Telaire T8000 series unit. Install near roof adjacent to intake air damper. Include weather rated enclosure.

T. Ambient Air Water Vapor Sensor (Master Ambient Sensor)

1. Provide one ambient air water vapor sensor in suitable enclosure mounted on north wall of building to measure outside air wet bulb temperatures.
2. Vapor sensor to have heated diffusion based sampling enclosure for low temperature (-20°F) operation.
3. Vapor sensor will be used to index all air handling units to economizer mode.
4. Vapor sensor shall be like Telaire or equal.
5. Provide calibration kit like Telaire 2075.

2.08 UTILITY MONITORING

- A. Refer to Specification Section 33 09 00.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Project Management as a Prime Contractor - Provide a designated project manager who, for duration of construction, will be responsible for the following:
1. Construct and maintain project schedule.
  2. On-site coordination with all applicable trades and subcontractors.
  3. Authorized to accept and execute orders or instructions from Owner/Engineer.
  4. Attend project meetings as necessary to avoid conflicts and delays.
  5. Make necessary field decisions relating to this scope of work.
  6. Coordination/Single point of contact.
- B. Electrical Installation
1. Furnish and install sensor, LAN, actuator, and interlock wiring as specified in Division 26 and 27 or shown on the plans. Connect controls in accordance with approved wiring diagrams. Wiring requirements are as follows:
    - a. 110 volt power and discrete control wiring: #12 AWG THHN.
    - b. Sensor/low voltage control wiring: #18 AWG twisted/shielded pair.
    - c. Communication wiring: #20 AWG twisted/shielded pair.
  2. Wiring installation minimum requirements, in accordance with Owners' standards, as follows:
    - a. All wiring installation shall be in accordance with Specifications 260500 and 260533.
    - b. All control wiring shall be completely independent of all other computer/technology wiring. Control system shall be connected to new/existing network system in only one place.
    - c. All shield to be grounded at the DDC panel, shields at the sensors or transducers to be folded back and taped.
    - d. All digital input and output signal wiring between field devices and panel must be "continuous run". No splices will be permitted. Connections (including shield) must be soldered and taped. Signal integrity must be checked with an oscilloscope and appropriate signal generator and lines so tagged. Inform the Engineer of any such work before implementation.
    - e. Do not route cable diagonally across the building.
    - f. Control shall not be routed in the same conduit as power.
    - g. Running wire above bar joist in roof/floor metal deck flutes is not permitted. Wire to be run above bottom chord of truss and supported with J-hooks and wire ties at maximum 4' o.c.
    - h. Line voltage (48 volts and above) shall be kept separated from low voltage within the control panel. Line voltage terminals shall be covered or protected in such a way that accidental contact with line voltage is prevented.
    - i. Temperature Control Contractor shall insure that no low voltage wiring is exposed to high voltage wiring within starters, control cabinets, etc. Insulation rating on control wiring must match high voltage wiring rating (above 300 volts) within starters or devices such as start/stop relays and current sensors must be mounted in companion enclosures. Follow guide lines in Div. 26 and/or the NEC, whichever is most strict.

3.02 START-UP AND COMMISSIONING

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
- B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

3.03 TRAINING

- A. The contractor shall provide factory trained instructor to give full instruction to designated personnel.

END OF SECTION 23 09 00

## SECTION 232123 – HYDRONIC PUMPS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Pump – Base-Mounted, End-Suction
  - 2. Pump Trim – Suction Diffuser

#### 1.02 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
- C. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.
- C. All pumps shall be in compliance with DOE pump efficiency requirements and include PEI(Pump Energy Index) energy label. Pumps shall be listed for PEI of less than 1.00.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 PUMP – BASE-MOUNTED, END-SUCTION

- A. Furnish and install a single stage pump as hereinafter specified and of a capacity and method of installation as shown on Drawings.
- B. The casing shall be constructed of close grained gray cast iron with smooth passageways and design for working pressure of 125 psi or 1-1/2 times discharge pressure, whichever is greater. Casing to have air vent cock at high point and drain plugs at low points.
- C. Casing shall have bronze removable wear ring around impeller inlet.
- D. Pump impeller shall be bronze, enclosed type shall be dynamic balanced.
- E. Pump shaft shall have removable bronze shaft sleeve at shaft seals.
- F. Pump Seals shall have spring loaded mechanical seal.
- G. Pump shall be equipped with set of oil lubricated anti-friction roller bearings.
- H. Pump and motor shall be mounted on common steel base and connected by means of flexible coupler.
- I. Pump motor and bed plate assembly shall be carefully mounted on concrete base and grouted per manufacturer recommendations in field by Mechanical Contractor. Great care shall be taken so that bed plate is level and pump and motor are properly aligned.
- J. Motor: to be heavy duty, greaseable ball bearing, open drip-proof. Reference drawings for VFD service. See Section 20 00 50 - Motors for Motor Performance. Motor sized for continuous operation without undue heating or overload.
- K. Pump shall not be run until the system is filled with water. Mechanical Contractor shall give particular notice of this to the Electrician who may desire to check the motor rotation.
- L. Chilled water pumps shall have integral drain pan below entire pump housing to catch condensate. Pipe to floor drain.
- M. Manufacturers:
  - 1. Bell & Gossett

2.03 PUMP TRIM - SUCTION DIFFUSER

- A. Cast iron construction rated at 175 psi at 250° F.
- B. 125 ANSI flanges.
- C. 90° entrance elbow with integral flow straightening devices. Flow straightening devices shall be of cast iron construction and shall be cast as integral part of suction diffuser.
- D. Bottom drain/blowdown connection. Pipe same size as connection to floor drain. Provide full port ball valve in pipe.
- E. Strainer

1. Fine mesh brass startup strainer.
  2. Stainless steel 1/8" hole permanent strainer.
- F. Sized for maximum 3 ft head pressure drop. Use increaser to upsize if required to meet pressure drop requirements.
- G. Manufacturers:
1. Bell & Gossett

### PART 3 - EXECUTION

#### 3.01 PUMP INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight.
- E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight.
- F. Set base-mounted pumps on concrete foundation. See Common Materials and Methods for Fire Suppression, Plumbing and HVAC, Section 20 00 50 for concrete pump base. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
  1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
  2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
  3. Gout pump base rails completely full of grout to top of base rails as recommended by manufacturer.

#### 3.02 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- B. Comply with pump and coupling manufacturers' written instructions.
- C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

### 3.03 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves full line size, not pump connection size.
- D. Install single gage with multiple input selector valve as detailed on drawings.
- E. Ground equipment according to Division 26 Specifications.
- F. Connect wiring according to Division 26 Specifications.

END OF SECTION 23 21 23

## SECTION 232213 – STEAM AND CONDENSATE PIPING SYSTEMS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This section includes piping, specialties and installation guidelines for the following systems:
  - 1. Low Pressure Steam
  - 2. Steam Condensate Return
- B. Steam specialties in this section include the following:
  - 1. Strainers.
  - 2. Safety valves.
  - 3. Pressure-reducing valves.
  - 4. Steam traps.
  - 5. Thermostatic air vents and vacuum breakers.

#### 1.02 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be in compliance with section 20 00 60, Pipe, Valves, Fittings and Hangers for Fire Suppression, Plumbing and HVAC.

#### 1.03 SUBMITTALS

- A. Product Data: For each type of the following:
  - 1. Pressure-reducing and safety valve.
  - 2. Steam trap.
  - 3. Air vent and vacuum breaker.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

#### 1.04 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
- B. If requested by Engineer, pipe fitters must provide history of experience with steam piping. If fitter has no experience with steam piping then a fitter with steam experience must be provided.

## PART 2 - PRODUCTS

### 2.01 DISCHARGE ELBOW AND DRIP PAN ARRANGEMENT

- A. Furnish and install where shown on Drawings a discharge elbow and drip pan arrangement and pipe from drain tapings to open-site drain.

### 2.02 STEAM TRAP - LOW PRESSURE - 0 TO 15 PSIG

- A. Float and Thermostatic Traps

1. Furnish and install for each low pressure main drip, unit heater, etc. and where shown.
2. Traps to have cast iron bodies, thermostatic air bypass, quick opening float valve with renewable seat and plunger and be designed for 15 psig working pressure.
3. Size in accordance with following table:

<u>TRAP SIZE</u>	<u>TRAP CAPACITY</u>
3/4"	100 #/hr condensate
1"	250 #/hr condensate
1-1/4"	600 #/hr condensate
1-1/2"	1200 #/hr condensate
2"	2500 #/hr condensate

- B. Manufacturers:

1. Armstrong
2. Modine
3. Sarco
4. Dunham
5. Hoffman
6. Watson-McDaniel

### 2.03 STRAINER - Y-TYPE

- A. Furnish and install where indicated on Drawings. Strainers to be full line size.
- B. Strainer body working pressure to be suitable for working pressure of system, but not less than 120 psig.
- C. Screen to be:
1. 20 mesh monel for 1/2" thru 2" pipe sizes.
  2. Perforated stainless steel for pipe sizes 2-1/2" and above.
- D. Strainer connections to be threaded for screwed piping, flanged for welded piping.
- E. Strainers to have full tapping size valved blowdown. Blowdown tapings above 1" may be 1" size. Valve to be quick opening full port ball valve.
- F. Manufacturers:

1. Hoffman
2. Webster
3. Crane
4. Fisher
5. Mueller
6. Keckley
7. Sarco

## 2.04 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

### A. Thermostatic Air Vents:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Body: Cast iron, bronze, or stainless steel.
4. End Connections: Threaded.
5. Float, Valve, and Seat: Stainless steel.
6. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
7. Pressure Rating: 125 psig
8. Maximum Temperature Rating: 350 deg F.
9. Manufacturers:
  - a. Armstrong International, Inc.
  - b. Barnes & Jones, Inc.
  - c. Dunham-Bush, Inc.
  - d. Hoffman Specialty; Division of ITT Industries.
  - e. Spirax Sarco, Inc.
  - f. Sterling

### B. Vacuum Breakers

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Body: Cast iron, bronze, or stainless steel.
4. End Connections: Threaded.
5. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
6. O-ring Seal: EPR.
7. Pressure Rating: 125 psig.
8. Maximum Temperature Rating: 350 deg F.
9. Manufacturers:
  - a. Armstrong International, Inc.
  - b. Dunham-Bush, Inc.
  - c. Hoffman Specialty; Division of ITT Industries.
  - d. Johnson Corporation (The).
  - e. Spirax Sarco, Inc.

2.05 VALVE - PRESSURE REDUCING - STEAM (PRV)

- A. Spring loaded, diaphragm operated, single seated type suitable for dead end service. Valves 2" NPS and smaller to have bronze body and screwed connections; valves 2-1/2" NPS and larger to have semi-steel body and flanged connections. Valves suitable for 150# or 250# working pressure with renewable stainless steel valve seats, V-port and stem.
- B. Valves operable with diaphragm above or below valve and installed with water accumulator in feeler line to prevent live steam coming in direct contact with diaphragm. Valves sized as recommended by the manufacturer for steam load and pressure range shown.
- C. Each pressure reducing station to include a steam safety valve set to relieve at 10 psig above the low pressure setting and located on low pressure side of reducing valve, a manual globe valve bypass around the reducing valve, strainer, gauges with syphons and cocks on each side of the reducing valve.
- D. Manufacturer:
  - 1. Spence ED

2.06 VALVE - STEAM SAFETY RELIEF (SV)

- A. ASME standard and tested, National Board Certified.
- B. 3/8" thru 1 1/4"
  - 1. Constructed with: bronze body, lever, bonnet, adjusting ring, brass ring pin, steel spindle, spring, washers, and malleable iron lifting gear.
  - 2. Maximum working: Pressure (psig) 300; Temperature (°F) 450.
- C. 1 1/2" thru 6"
  - 1. Constructed with: cast iron body and yoke, bronze seat, bushing, adjusting rings, steel spring, spindle and washer, brass ring pins.
  - 2. Maximum Working: Pressure (psig) 250; Temperature (°F) 450.
- D. Manufacturer:
  - 1. J.E. Lonergan
  - 2. Kunkle
  - 3. Nicholson
  - 4. Approved Equal.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS

- A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

- B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to a point outside building as indicated on Drawings. Install drip pan elbow on discharge of safety valves and pipe drip pan to floor drain. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

### 3.02 PIPING INSTALLATION

- A. Install piping of type as indicated in Section 20 00 60.
- B. Contractor installing steam pipe shall be familiar with steam pipe installation including anchor installation, expansion joint, guides, proper pitch, etc.
- C. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Use indicated piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- D. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping to permit valve servicing.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- M. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
- N. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
- O. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
- P. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

- Q. Install valves according to Section 20 00 60. Note: No ball valves or quick opening valves allowed on steam systems unless specifically shown.
- R. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- U. Install expansion loops, expansion joints, anchors, and pipe alignment guides shown on drawings and as specified.
- V. Identify piping as specified in Section 20 00 50.
- W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
  - 1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet
  - 2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.
- X. Install control valves with actuator rotated at 45° from vertical to minimize actuator overheating, i.e. actuator to not be directly above valve.

### 3.03 STEAM-TRAP INSTALLATION

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, test valve and full-port ball valve downstream from trap unless otherwise indicated.

### 3.04 PRESSURE-REDUCING VALVE INSTALLATION

- A. Install pressure-reducing valves in accessible location for maintenance and inspection.
- B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
- C. Install gate valves on both sides of pressure-reducing valves.
- D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.
- E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to details.

- F. Install strainers upstream for pressure-reducing valve.
- G. Install safety valve downstream from pressure-reducing valve station.

### 3.05 SAFETY VALVE INSTALLATION

- A. Install safety valves according to ASME B31.9, "Building Services Piping."
- B. Pipe safety-valve discharge without valves to atmosphere outside the building.
- C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
- D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

### 3.06 HANGERS AND SUPPORTS

- A. See Section 20 00 60 for hanger installations.
- B. See Section 20 00 10 for hanging attachment to building construction.

### 3.07 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install traps and control valves in accessible locations close to connected equipment.
- C. Install vacuum breakers downstream from control valve, close to coil inlet connection.
- D. Install a drip leg at coil outlet.

### 3.08 FIELD QUALITY CONTROL

- A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:
  - 1. Leave joints, including welds, un-insulated and exposed for examination during test.
  - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
  - 3. Flush system with clean water. Clean strainers.
  - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
- B. Perform the following tests on steam and condensate piping:
  - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
  3. 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.
- C. Prepare written report of testing.

END OF SECTION 23 22 13

## SECTION 232224 – STEAM CONDENSATE PUMP – STEAM MOTIVE

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Steam Condensate pumps steam motive.

#### 1.02 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, tank capacity, type of construction, and accessories for each type of product indicated.
- B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
- C. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

### PART 2 - PRODUCTS

#### 2.01 STEAM CONDENSATE PUMP – STEAM MOTIVE

- A. Furnish and install where shown on Drawings, a pressure driven condensate pump trap receiver package as noted on Drawings. Capacity indicated is for 200°F water.
- B. Pump Trap body shall be constructed of cast iron with all stainless steel intervals. The mechanism shall incorporate Incolnel X-750 springs for a long service life. Springs made of materials other than Incolnel shall not be accepted. Single compression springs shall not be accepted.
- C. Pump Trap shall have a 3-year No Fail Mechanism Warranty as standard.
- D. Motive Force. The Pump trap shall utilize steam, compressed air or inert gas to remove condensate from the receiving vessel.
- E. Duplex pump package design with a maximum operating pressure of 125 psig.
- F. ASME code carbon steel receiver shall measure 12" x 48" or 24" x 48", depending on the flash and condensate loads. Packages have 0" fill head, 6" fill head, 12" fill head or 24" fill head designs available.

- G. Package shall be pre-piped between the pump inlet and receiver outlet as shown as shown on drawings CDF1087 & CD1088, and include isolation valves, bronze or stainless steel NPT check valves and unions.
- H. Pumps shall require no electricity for operation.
- I. The Pump Traps & Receiver shall include a bronze water level gauge with shut off valves.
- J. Provide Pump Traps with removable insulation cover.
- K. Manufacturer's standard painting shall be factory applied.
- L. Provide with manufacturers PRV to adjust motive steam to proper pressure.
- M. Receiver and cast iron pump ASME code III construction (150 PSIG at 450°F).
- N. Pumps and inlet locations to be as shown on Drawings.
- O. Manufacturer:
  - 1. Armstrong Intl, Inc. Model DPT-3508 Low Boy  
With Pump Trap Receiver Package

### PART 3 - EXECUTION

#### 3.01 PUMP INSTALLATION

- A. Comply with manufacturer's instructions.
- B. Install pumps with access for periodic maintenance all service required.
- C. Set pumps on concrete foundation. See Common Materials and Methods for Fire Suppression, Plumbing and HVAC, Section 20 00 50 for concrete pump base.

#### 3.02 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Condensate to drain down into receiver, condensate pipe shall not rise into receiver.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Install check valve, gate valve, and globe valve at pump discharge connections for each electric-driven pump.
- E. Pipe drain to nearest floor drain for overflow and drain piping connections.
- F. Install full-size vent piping as indicated.

END OF SECTION 23 22 24

## SECTION 232300 – REFRIGERANT PIPING

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

#### 1.02 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A, R407C, R507:
  - 1. High Side: 650 psig.
  - 2. Low Side: 360 psig.

#### 1.03 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe tube and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
  - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.04 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

#### 1.05 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

## PART 2 - PRODUCTS

### 2.01 COPPER TUBE AND FITTINGS

- A. See Section 20 00 60 for Copper tube and fittings.

### 2.02 VALVES AND SPECIALTIES

- A. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly, 680 psig.
4. Pressure Rating: Factory test at minimum.
5. Maximum Operating Temperature: 250 deg F.

- B. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. Working Pressure Rating: 550 psi, capable of handling up to 700 psi.
5. Temperature operation range of -40°F to 300°.
6. Full flow valve with 0 pressure drop.
7. Bi-directional flow.
8. Service port.
9. Compatibility with R410A and PVE (Polyvinyl Ether Oil) oil.

- C. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Provided as part of refrigeration equipment package.

### 2.03 REFRIGERANTS

- A. Provided by equipment manufacturer: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- B. ASHRAE 34, R-22, R-134A, R-410A, R407C, R-507 and R-404A.

## PART 3 - EXECUTION

### 3.01 VALVE AND SPECIALTY APPLICATIONS

- A. Install flexible connectors at compressors.

### 3.02 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Contractor must have factory provided refrigeration piping schematic showing all lengths, sizes, double suction risers and inverted traps prior to refrigeration installation. Engineer may stop work if piping schematic is not present.
- C. Install refrigerant piping according to ASHRAE 15.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping adjacent to machines to allow service and maintenance. Drop pipe to floor to allow installation of sound enclosure over chiller.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- M. Slope refrigerant piping as follows:
  - 1. Install traps and double risers to entrain oil in vertical runs.
  - 2. Liquid lines may be installed level.
  - 3. Suction line shall slope down in direction of flow.
- N. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- O. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- P. Seal penetrations through fire and smoke barriers according to Section 20 00 50.
- Q. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

- R. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- S. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."
- T. When installing piping on unistrut place piping hangers at random distance from each other to minimize harmonics.

### 3.03 HANGERS AND SUPPORTS

- A. Support multi-floor vertical runs at least at each floor.

### 3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Comply with ASME B31.5, Chapter VI.
  - 2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
  - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
    - a. Fill system with nitrogen to the required test pressure.
    - b. System shall maintain test pressure at the manifold gage throughout duration of test.
    - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

### 3.05 SYSTEM CHARGING

- A. Charge system using the following procedures:
  - 1. Install core in filter dryers after leak test but before evacuation.
  - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
  - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
  - 4. Charge system with a new filter-dryer core in charging line.

### 3.06 ADJUSTING

- A. Start up by certified manufacturer representative.
- B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

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## SECTION 232500 – HVAC WATER TREATMENT

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. The provisions of the General Conditions, Supplementary Conditions, Sections included under Division 1, General Requirements, and Sections 20 00 10 and 20 00 50 of this Division are included as a part of this Section as though bound herein.
- B. Refer to Details, Schematics and Schedules on the Drawings for additional requirements.

#### 1.02 SECTION INCLUDES

- A. Treatment Materials
- B. Equipment

#### 1.03 SUMMARY

- A. Provide the labor, chemicals, materials, equipment, appliances, services and transportation, and perform the operations in connection with the construction and installation of the Work. Work shall be as herein specified and as denoted on the accompanying Drawings.
- B. Systems to receive treatment include:
  - 1. Heating Water System
  - 2. Chilled Water System
- C. Work of this Section includes the following:
  - 1. Cleaning of piping systems.
  - 2. Chemical treatment equipment.
  - 3. Treatment for closed systems.

#### 1.04 SUBMITTALS

- A. Submit shop drawings indicating system schematics, equipment locations, and controls schematics.
- B. Submit product data indicating chemical treatment materials, chemicals, and equipment.
- C. Submit manufacturer's installation instructions under provisions of Division 1.
- D. Submit reports indicating startup of treatment systems is completed and operating properly.
- E. Submit reports indicating analysis of system water after cleaning and after treatment.

F. Operating and Maintenance Data

1. Submit operation and maintenance data under provisions of Division 1.
2. Include data on chemical feed pumps, conductivity controllers, chemicals and other equipment including spare parts lists, procedures, and treatment programs.
3. Include step by step instructions on test procedures including target concentrations.

1.05 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum 3 years experience. Company shall have local representatives with water analysis laboratories and full time service personnel.
- B. Conform to applicable EPA code for addition of non-potable chemicals to building mechanical systems, and for delivery to public sewage systems.

C. MAINTENANCE

1. Maintenance Service

- a. Furnish testing service, warranty and maintenance of treatment systems for one (1) year from date of Substantial Completion.
- b. Furnish monthly technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two (2) copies of field service report after each visit.
- c. Furnish laboratory and technical assistance services for warranty period.
- d. Include training course for operating personnel, instructing them on installation, care, maintenance, testing and operating of water treatment systems. Arrange course at startup of systems.
- e. Furnish on site inspections of equipment during schedule or emergency shutdown to properly evaluate success of water treatment based upon these inspections.

2. Maintenance Materials

- a. Provide sufficient chemicals for treatment and testing during warranty period.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Watcon
- B. DuBois
- C. Nalco
- D. Approved equal

## 2.02 TREATMENT MATERIALS

- A. System Cleaner
  - 1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
- B. Closed System Treatment (Water)
  - 1. Sequestering agent to reduce deposits and adjust pH.
  - 2. Corrosion inhibitors.

## 2.03 EQUIPMENT

- A. Water Meters: Displacement type cold water meter with sealed, tamper proof magnetic drive, impulse contact register, single pole, double throw dry contact switch. (Water meters to be connected to building management system by automatic temperature control contractor.) Manufacturer: Neptune Pro Read T-10.
- B. Filter Feeder: 5 gallon, 300 psig rating, vertical style with dish bottom with 3/4" bottom drain, 3/4" inlet and outlet, leg stands, with 10 extra filter bags – 5 at 20 microns and 5 at 5 microns. Filter feeder to be like Neptune FTF-5DB or equal.

## PART 3 - EXECUTION

### 3.01 SYSTEMS TO BE CLEANED AND FLUSHED

- A. Heating Water System.
- B. Chilled Water System.

### 3.02 INSTALLATION

- A. Install filter feeder in a 2 valve bypass arrangement around circulating pump in order to create a pressure differential. A 3/4 inch feeder lead-in line shall be taken from the circulating line on the discharge side of the pump. A 3/4 inch feeder outlet line shall run to the circulating line on the suction side of the pump. Feeder line shall be installed with a line size shutoff valve and union connection on the filter feeder.
- B. The chemical treatment systems shall be completely wired and ready to operate by the time of the initial system start-up. The hydronic systems shall not be operated without the proper chemical treatment specified in this section. Wiring of water meter and solenoid back to controller shall be provided by Division 26 Contractor.
- C. Install make-up meters in the closed loop systems, which typically includes heating and chilled water system. Meters to be connected to control system. Coordinate signal required with the control contractor.
- D. The final flushing shall be witnessed by the Owner.

### 3.03 PREPARATION AND CLEANING PROCEDURES

#### A. Preparation

1. Systems shall be operational, filled, started and vented prior to cleaning. Use water meter to record capacity in each system. Record the volume of water required to fill all closed loop systems and report the amount to the Engineer in writing.
2. Place terminal control valves in open position during cleaning.

#### B. Cleaning Sequence

1. Remove and clean all new and existing strainers prior to start-up.
2. Circulate for 48 hours then drain system as quickly as possible. Refill with clean water, circulate for 24 hours then drain. Refill with water and repeat until system cleaner is removed.
3. Flush open systems with clean water for one hour minimum. Drain completely and refill.
4. Remove, clean and replace strainer screens.
5. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly and reassembly of components as required.

### 3.04 CLOSED SYSTEM TREATMENT

- A. Provide conductivity, hardness and pH test on each system. Confirm that all parameters of the water in the system is in compliance with the equipment installed in the system.
- B. Introduce chemical treatment into the system in the filter feeder as required by test.
- C. Make a 12 month return trip, re-conduct test and add chemical treatment as required. Provide written report to owner and engineer detailing all work required.
- D. Confirm that water in heating water system is in the parameters as typically required.

END OF SECTION 23 25 00

## SECTION 233113 – METAL DUCTS

### PART 1 – GENERAL

#### 1.01 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Duct Liner.
3. Round ducts and fittings.
4. Dual wall insulated duct and fittings
5. Access doors
6. Sheet metal materials.
7. Sealants and gaskets.
8. Hangers and supports.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

#### 1.02 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated.

1. Static-Pressure Classes:

- a. Supply Ducts (Upstream from Air Terminal Units): 4-inch wg.
- b. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg.
- c. Supply Ducts (Constant Volume Systems): 2-inch wg.
- d. Return Ducts (Negative Pressure): 2-inch wg.
- e. Exhaust Ducts (Negative Pressure): 1.5-inch wg.

2. Leakage Class:

- a. Round Flat Oval Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg.
- b. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.
- c. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.

- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

### 1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Factory- and shop-fabricated ducts and fittings.
  - 3. Duct layout indicating sizes, configuration, and static-pressure classes.
  - 4. Elevation of top of ducts.
  - 5. Dimensions of main duct runs from building grid lines.
  - 6. Fittings.
  - 7. Reinforcement and spacing.
  - 8. Seam and joint construction.
  - 9. Penetrations through fire-rated and other partitions.
  - 10. Equipment installation based on equipment being used on Project.
  - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
  - 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
  - 13. The construction documents are not fabrication drawings and are not intended to show all offsets as required for proper ductwork installation. Contractor to field verify all existing conditions and prepare fabrication drawings based on existing conditions. All additional offsets shall be included in bid price.
  - 14. Submit 2 copies of sheet metal fabrication drawings to Testing and Balancing Contractor for his review prior to submitting to engineer.
- C. Delegated-Design Submittal:
  - 1. Sheet metal thicknesses.
  - 2. Joint and seam construction and sealing.
  - 3. Reinforcement details and spacing.
  - 4. Materials, fabrication, assembly, and spacing of hangers and supports.
- D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
  - 2. Suspended ceiling components.
  - 3. Structural members to which duct will be attached.
  - 4. Size and location of initial access modules for acoustical tile.
  - 5. Penetrations of smoke barriers and fire-rated construction.
  - 6. Items penetrating finished ceiling including the following:
    - a. Lighting fixtures.
    - b. Air outlets and inlets.
    - c. Speakers.
    - d. Sprinklers.
    - e. Access panels.

## PART 2 - PRODUCTS

### 2.01 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Exposed ductwork in finished areas shall have "paint-grip" finish. Ductwork will be field painted.

### 2.02 DUCT LINER

- A. Where noted on Drawings, this Contractor shall insulate inside of duct with liner.
- B. All exposed leading edges and transverse joints shall be neatly butted without gaps. All edges shall be factory coated. All field cut edges shall be coated with approved coating/sealant. Manville Superseal Permacote or equal.
- C. Nominal insulation thickness to be 1"
- D. Insulation density shall be 1 ½ #/cu. ft.
- E. Insulation shall have an air stream surface with an acrylic coating and a biocidal component, which satisfies the requirements of ASTM C1071 – "Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Liner Material)." The material must not support the growth of mold and fungi when tested in accordance with ASTM C665. NBFU approved. All components of duct liner insulation must not exceed 25 flame or 50 smoke developed ratings.
- F. Manufacturers:
  - 1. Knauf Duct Liner EM
  - 2. JohnsManville Linacoustic RC
  - 3. Approved equal.

## 2.03 ROUND DUCTS AND FITTINGS

- A. See Floor Plans for dual wall duct requirements.
- B. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Lindab Inc.
    - b. McGill AirFlow LLC.
    - c. SEMCO Incorporated.
    - d. Sheet Metal Connectors, Inc.
    - e. Spiral Manufacturing Co., Inc.
    - f. United Sheet Metal.
    - g. LaPine
    - h. Eastern Sheet Metal
    - i. JTD Spiral Inc.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Dual-walled ductwork and internally lined ductwork if finished or public areas shall have "paint-grip" finish. Ductwork will be field painted.

## 2.04 DUAL WALL INSULATED DUCT AND FITTINGS

- A. General
  - 1. Construct to pressure classification as noted in Part 1 of this specification section.
  - 2. Construction in general shall be comprised of an airtight, outer pressure shell, a 1" insulation layer and perforated metal inner liner that completely covers the insulation throughout the system.

3. Insulation shall have the following UL maximum rating: Flame Spread 25; Smoke Developed 50.
4. Outer pressure shell and inner liner shall be manufactured from galvanized steel, meeting ASTM A-527-67 in following minimum gauges:

NOMINAL DUCT SIZE	3-6"	7-20"	21-34"	35-48"	49"&UP
Duct-Outer Pressure Shell	26*	24*	22*	20*	16**
Duct-Inner Perforated Liner	24*	24*	24*	24*	20
Fitting-Outer Pressure Shell	20	20	20	18	16
Fitting-Inner Perforated Liner	20	20	20	20	20

\* Gauges if made from spiral duct

\*\* Longitudinal seam, continuous butt weld

5. Divided flow fittings are to be made as separate fittings, not tap collars into duct sections, with the following construction requirements:
    - a. Sound airtight continuous welds at intersection of fitting body and tap.
    - b. Tap liner securely welded to inner liner with weld spacing not to exceed 3".
    - c. Insulation to be packed around branch tap area for complete cavity filling.
    - d. Branch connection is to be carefully fit to cut- out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and air flow disturbances.
  6. All seams in pressure shell of fittings are to be continuous welded. Galvanized areas that have been damaged by welding shall be coated with corrosion resistant aluminum paint.
  7. Perforations are not to exceed 3/32" diameter.
  8. Inner liners of both duct and fittings are to be adequately supported by metal spacers welded in position to maintain spacing and concentricity.
- B. Coupling: an inner coupling should be provided to align the inner lining to maintain good air flow conditions equivalent to standard round high pressure duct joints. Butt joints are not suitable for inner liner. This alignment may be accomplished by liner of fitting for slip-joint into pipe or by use of double, concentric coupling with two couplings held by spacers for rigidity and wall spacing. Above 34" I.D., a separate coupling should be provided for inner alignment with pressure shells joined by angle ring flanged connections.
- C. Insulation Ends: at end of an insulated section or run, where internally insulated duct connects to uninsulated spiral duct or fitting, fire damper or flex, an insulation end fitting shall be installed to bring the outer pressure shell down to nominal size.
- D. Flat Oval Dual Wall Duct and Fitting
1. Within available sizes, flat oval internally insulated duct shall be manufactured from spiral flat oval duct in the following U.S. Standard gauge galvanized steel:

<u>NOMINAL DUCT WIDTH</u>	<u>TO 22"</u>	<u>23-46"</u>	<u>47-72"</u>
Duct-Outer Pressure Shell	24 ga.	22 ga.	20 ga.

Inner Perforated	24 ga.	24 ga.	24 ga.
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2. Bracing and reinforcement are to be as recommended by manufacturer for size and pressure conditions in duct. Joints shall be made by using an alignment coupling to connect liners. Pressure shells of ducts below 42" Major Axis dimensions shall be joined by reinforced 18 gauge couplings. Bolted angle flanges with neoprene gaskets shall be used to join pressure shells for ducts above 42" in width.
3. Dual wall flat oval ductwork for sizes not available in spiral construction shall be manufactured in 4' modular sections to the following minimum galvanized metal gauges:

<u>NOMINAL DUCT WIDTH</u>	<u>TO 34"</u>	<u>35-38"</u>	<u>49"&amp;UP</u>
Duct-Outer	20 ga.	18 ga.	16 ga.
Pressure Shell			
Inner Perforated	20 ga.	20 ga.	18 ga.
Liner			

4. When maximum width of oval duct exceeds 40" or when maximum height exceeds 26" angle iron companion flanges shall be welded to outer shell for stiffness and assembly. Alignment of inner lining shall be by reinforced slip-joint couplings of 18 gauge minimum. Flat oval duct below size limits shall be assembled by double slip-joint couplings formed from 18 gauge sheet metal secured together by welded spacers.
5. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Lindab Inc.
  - b. McGill Air Flow LLC.
  - c. SEMCO Incorporated
  - d. Sheet Metal Connectors, Inc.
  - e. United Sheet Metal
  - f. LaPine
  - g. Eastern Sheet Metal
  - h. JTD Spiral Inc.

## 2.05 ACCESS DOORS (AD) (HIGH PRESSURE)

- A. Construction - steel with 1/2" of fiberglass insulation between door and door pan. Sponge rubber gasketing to be on inside of door frame and between duct and door frame. Door metals to be of sufficient gauge for minimizing leakage at various duct pressures. Hinges not to exceed 12" apart and two handle-type latches to be used for sides exceeding 12".

1. Manufacturers:

- a. Ventfabrics Ventlok Door
- b. Buensod Stacey Type F
- c. Approved equal

## 2.06 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G60.
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.07 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
  - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
  - 2. Tape Width: 4 inches.
  - 3. Sealant: Modified styrene acrylic.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 7. Service: Indoor and outdoor.
  - 8. Service Temperature: Minus 40 to plus 200 deg F.
  - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. Water-Based Joint and Seam Sealant:
  - 1. Application Method: Brush on.
  - 2. Solids Content: Minimum 65 percent.
  - 3. Shore A Hardness: Minimum 20.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. VOC: Maximum 75 g/L (less water).
  - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 8. Service: Indoor or outdoor.
  - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
  - 1. General: Single-component, acid-curing, silicone, elastomeric.
  - 2. Type: S.
  - 3. Grade: NS.

- 4. Class: 25.
- 5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

- 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
- 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
- 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

## 2.08 HANGERS AND SUPPORTS

- A. Hanger Rods for Non-corrosive Environments: Cadmium-plated steel rods and nuts. Clean/degrease for painting where applicable.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure Showing 5-1, "Rectangular Duct Hangers Minimum Size," and Figure showing 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports:
  - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

## PART 3 - EXECUTION

### 3.01 DUCT INSTALLATION

- A. **Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.**
- B. Install dual wall insulated duct in exposed areas as noted on Drawings.
- C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- D. Install round ducts in maximum practical lengths.
- E. Install ducts with fewest possible joints.

- F. Install commercial dishwasher exhaust ductwork with pitch back to dishwasher. Ductwork shall have smooth interiors for proper drainage.
- G. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- J. Install ducts with a clearance that will allow for insulation thickness.
- K. Route ducts so that they do not pass through transformer vaults, electrical equipment rooms, stairwell enclosures and elevator equipment rooms.
- L. Where ducts pass through non-fire-rated interior partitions and exterior walls, cover the opening between the partition and duct or duct insulation with sheet metal flanges (picture frames) of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- M. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- N. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with "Intermediate Level" standards as identified in SMACNA's "Duct Cleanliness for New Construction Guidelines." All ducts and air openings on equipment shall be covered and protected throughout construction until ready for use.

### 3.02 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table showing 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
- B. Seal Classes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table showing 1-1, "Standard Duct Sealing Requirements."

### 3.03 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter for, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 2. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

3. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table showing 5-1, "Rectangular Duct Hangers Minimum Size," and Table showing 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports. Clean/degrease where painting is to occur.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- G. Install stiffener's, turning vanes, and or air straighteners as required to stop objectionable duct oil canning, or fan surge to the satisfaction of the engineer.

### 3.04 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### 3.05 DUCT SCHEDULE

- A. Fabricate supply, return, outdoor air, and relief air ducts with galvanized sheet steel unless noted otherwise on drawings or within specifications.
- B. Ductwork exhausting high moisture airstreams, such as shower rooms and locker rooms, shall be fabricated from aluminum or stainless steel.
- C. Intermediate Reinforcement:
  1. Galvanized-Steel Ducts: Galvanized steel.
- D. Elbow Configuration:
  1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Rectangular Elbows."
    - a. Velocity 1000 fpm or Lower:
      - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      - 2) Mitered Type RE 4 without vanes.

- b. Velocity 1000 to 1500 fpm:
  - 1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Vanes and Vane Runners," and Figure showing, "Vane Support in Elbows."
- c. Velocity 1500 fpm or Higher:
  - 1) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Vanes and Vane Runners," and Figure showing, "Vane Support in Elbows."
- 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure showing, "Round Duct Elbows."
  - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table showing, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
    - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
    - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
    - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
  - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
  - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.
- E. Branch Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry. No spin-in type fittings allowed.
  - 2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
    - a. Velocity 1000 fpm or Lower: 90-degree tap.
    - b. Velocity 1000 to 1500 fpm: Conical tap.
    - c. Velocity 1500 fpm or Higher: 45-degree lateral.
- F. ESCUTCHEONS:
  - 1. For all duct penetrations thru walls into finished areas duct shall have neat shop fabricated picture frame escutcheon on finished side of wall.
    - a. This applies to both round and square duct work.
    - b. Externally insulated ducts to have escutcheon oversized by thickness of insulation.

- c. Ducts without insulation to have escutcheon tight to exterior of duct.
- d. Escutcheon to be fastened to wall and not duct.
- e. Escutcheon to be of quality finish and paintable.

END OF SECTION 23 31 13

## SECTION 233119 – HVAC HOUSINGS AND PLENUMS

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Division 23 Specification Sections for Fans and Coils.

#### 1.02 SUMMARY

- A. This Section includes HVAC casings for field-erected air-handling systems and for housing mechanical equipment.

#### 1.03 DEFINITIONS

- A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula  $\text{Btu} \times \text{in.} / \text{h} \times \text{sq. ft.} \times \text{deg F}$  at temperature differences specified. Values are expressed as Btu.
  - 1. Example: Apparent Thermal Conductivity (k-Value): 0.26.

#### 1.04 SUBMITTALS

- A. Product Data: For factory-fabricated casings, sealant materials, and acoustic liner materials.
- B. Shop Drawings: Include plans, elevations, sections, components, and attachments to other work. Show fabrication and installation details of the following:
  - 1. Reinforcement and spacing.
  - 2. Seam and joint construction.
  - 3. Access doors, including frames, hinges, and latches.
  - 4. Filter, coil, humidifier, and other apparatus.
  - 5. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
  - 6. Interior lighting, including switches.
- C. Product Certificates: For factory-fabricated casings, signed by product manufacturer.
  - 1. Show sound-absorption coefficients in each octave band lower than those scheduled when tested according to ASTM C 423.
  - 2. Show airborne sound transmission losses lower than those scheduled when tested according to ASTM E 90.
- D. Welding certificates.

1.05 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for HVAC casing joint and seam welding.

1.06 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.01 HOUSINGS AND PLENUMS

A. General

1. Housing shall be built with prefabricated 4" insulated panels and be completely designed and detailed for orientation and configuration as shown on drawings.
2. All dimensions shall be field verified prior to fabrication. The housing will be completely field erected.
3. Housing manufacturer shall furnish 1/2" scale fabrication/erection drawings and installation instructions showing all dimensions, panel connection types, connection methods and door locations. Each piece shall be marked to match location shown on the drawings.
4. Complete housing shall be designed to withstand and remain airtight with 4" positive and 2" negative static pressure. The panels shall not deflect not more than 1/240 of the span. Any air noises shall be fixed to satisfaction of the Owner/Engineer.
5. All fasteners to be stainless steel.

B. Panels

1. Panels shall be dual wall 4" thick, acoustically insulated with maximum heat transfer of .07 Btu/hr/SF° F. Panels shall be of interlocking tongue and groove type design. Exterior skin to be a minimum 18 gauge solid G-90 galvanized steel. Interior skin for wall panels to be solid 22 gauge, G-90 galvanized steel. Interior skin for floor panels shall be 18 gauge, G-90 galvanized steel.
2. Panels to be completely framed with 18 gauge galvanized steel channels. Box frames to be welded from side rail to end cap, including corners. Panels to have stiffeners welded to exterior skin and structurally attached to interior skin at 16" o.c.
3. Panel filler/insulation shall meet or exceed the following criteria when tested in accordance with ASTM – E84, NFPA – 255 and UL 723 test methods 25/50 flame/smoke index.

C. Access Doors

1. Access doors to be 4" thick with solid 18 gauge galvanized steel on both sides.
2. Access doors shall be provided with a minimum of two hinges and two wedge-lever-type latches operable from both sides of the door. Access doors shall always open against air pressure.
3. Access doors shall have single gasket for air tight fit with positive sealing.

4. Access doors to have 12" x 12" vision panels where noted on the drawings. Vision panels shall be double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.

D. Openings

1. The panel manufacturer shall provide all duct and fan openings. All piping and conduit penetrations shall be field located and cut and sealed.

E. Manufacturers:

1. Rink
2. Tempmaster
3. United Sheet Metal
4. Semco
5. Aerosonics
6. Price Industries

2.02 FILTER HOLDING FRAME

A. Size, capacity and arrangement as shown on the Plans.

- B. Holding frames shall be constructed of 16-gauge galvanized steel. All corners shall be mitered, continuously welded and ground to form a smooth surface between the frame sealing surface and the gasket at the corner points of the sealing flange. All sheared edges of the frame shall be de-burred before final assembly.

- C. Holding frames shall be designed to hold a 2" thick pre-filter and 4" thick final filter and shall have adequate bearing surface for assembly and mounting. The holding frame shall have 16 pre-punched mounting holes to facilitate proper alignment and assembly. Two rows of dimples shall be spaced to center a filter and pre-filter when both are used in combination in a single frame. Holding frames shall also be equipped with pre-punched lances to accommodate various types of stainless steel fasteners. A closed-cell ept/polyethylene/butyl gasket shall be attached to the sealing flange of each holding frame.

- D. Include all required stainless steel spring loaded fasteners to properly support and hold filter elements within the holding frame.

- E. Install and assemble according to manufacturer's written instructions. Provide all miscellaneous hardware (nuts, bolts, washers, etc) as required for a complete installation. Hardware shall be constructed of galvanized steel.

F. Manufacturers:

1. Flanders
2. AAF
3. FARR
4. Approved Equal

2.03 DIFFERENTIAL PRESSURE GAUGE (MAGNAHELIC)

- A. A magnahelic air filter gauge for measuring resistance to air flow through the filters shall be installed. Provide one for each bank of pre-filters and each bank of final filters. The gauge shall be diaphragm actuated with pointer zero adjustment and have 3 7/8" diameter white dial with black figures and graduations. Accessories shall include surface mounting bracket with screws and two each, static pressure tips, 5' lengths aluminum tubing and vent valves.
- B. Housing constructed of die cast aluminum with a baked enamel finish.
- C. Accuracy of plus or minus 2% of full scale at 70° F. Ambient temperature range 20° F to 140° F. Provide operating range as best suits job conditions and as recommended by filter element supplier.
- D. Install according to manufacturer's written instructions. Provide all miscellaneous hardware (screws, tubing, compression fittings) as required for a complete installation.
- E. Manufacturers:
  - 1. Dwyer
  - 2. Approved Equal

2.04 PRE-FILTER ELEMENTS

- A. Size as shown on the Plans. Provide 3 complete sets of filters.
- B. Each filter element shall be 2" thick with 10 pleats per foot and consist of a cotton and synthetic media, heavy gauge expanded metal support grid and enclosing frame. Filters shall be listed by UL as Class 2.
- C. The filter media shall have an average efficiency of 20%, and have an average arrestance of 85-90% (MERV-5) based on ASHRAE Test Standard 52.2. Initial resistance at 500 ft/min shall not exceed 0.30".
- D. The media support grid shall be constructed of heavy gauge (.013) expanded electro-galvanized metal with grid members being no less than .025" wide, providing an open area not less than 96%. The grid shall be 100% bonded to the media on the air exiting side to eliminate media vibration and pull-away. The grid shall be formed to provide a uniform V-shaped pleat, with the open area on the air exiting side matching the open area on the air entering side.
- E. The enclosing frame shall be constructed of a rigid, high wet-strength beverage board. Diagonal support members shall be bonded to both the air entering and the air exiting sides of each pleat. The enclosing frame shall be chemically bonded to the filter pack on all four sides.
- F. Manufacturers:
  - 1. Flanders
  - 2. AAF
  - 3. FARR
  - 4. Approved Equal

## 2.05 FINAL FILTER ELEMENTS

- A. Size as shown on the Plans. Provide 3 complete sets of filters.
- B. Each filter element shall be 4" thick and consist of a synthetic or glass media, heavy gauge expanded metal support grid, enclosing frame and mesh face guards. Filters shall be listed by UL as Class 2.
- C. Filter Media: The filter media shall be 20 mil thick (minimum) with an average efficiency of 30-35%, and have an average arrestance of 90% (MERV-8) based on ASHRAE Test Standard 52.2.
- D. The media support grid shall be constructed of heavy gauge (.013) electro-galvanized expanded metal with grid members being no less than .025" wide, providing an open area of not less than 96%. The grid shall be 100% bonded to the media on the air exiting side to eliminate media vibration and pull-away. The grid shall be formed to provide a uniform V-shaped pleat, with a matching open area on the air exiting and air entering sides.
- E. The enclosing frame shall be constructed of die-cut, heavy duty, foil coated beverage board. The filter element shall be a standard size model as noted on the Plans. The enclosing frame shall be chemically bonded to the filter pack on all four sides.
- F. Manufacturers:
  - 1. Flanders "Precision Cell"
  - 2. AFF
  - 3. FARR
  - 4. Approved Equal

## 2.06 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- C. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- D. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- E. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Field measure all existing conditions. This contractor is responsible for fit.

- B. Examine concrete bases and roof curbs for compliance with requirements for conditions affecting installation and performance of HVAC casings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 INSTALLATION

- A. Install casings according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply with recommended spacing of sheet metal screws and with requirements for casing sealing and trim positioning.
- B. Apply sealant to joints, connections, and mountings.
- C. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- D. Support casings on floor or foundation system. Secure and seal to base.
- E. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.
- F. Align casings accurately at connections.
- G. Maintain duct seal class integrity throughout casings.

### 3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
  - 1. Give seven days' advance notice to Engineer prior to testing.
  - 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
  - 3. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
  - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION 23 31 19

## SECTION 233300 – AIR DUCT ACCESSORIES

### PART 1 – GENERAL

#### 1.01 SUMMARY

A. Section Includes:

1. Materials.
2. Counter balanced backdraft dampers.
3. Manual volume dampers.
4. Fire dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Control dampers.
8. Flange connectors.
9. Turning vanes.
10. Duct-mounted access doors.
11. Flexible connectors.
12. Flexible ducts.
13. Duct accessory hardware.
14. Duct Silencer

#### 1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work on  $\frac{1}{4}" = 1'-0"$  scale drawings.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
  - a. Special fittings.
  - b. Manual volume damper installations.
  - c. Control damper installations.
  - d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
2. The construction documents are not fabrication drawings and are not intended to show all offsets as required for proper ductwork installation. Contractor to field verify all existing conditions and prepare fabrication drawings based on existing conditions. All additional offsets shall be included in bid price.

C. Operation and maintenance data.

1.03 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90.
  - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 COUNTER BALANCED BACKDRAFT DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck EM
  - 2. Ruskin CBD2.
  - 3. United Enertech
  - 4. Pottorff
  - 5. NCA Mfg.
- B. Description: Gravity balanced with adjustable weights. Adjustable open from .01" to .15".
- C. Frame: 0.090-inch- thick 6063T5 extruded aluminum, with welded corners and 12 gauge brace at each corner.
- D. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch- thick, roll-formed aluminum with vinyl blade edge seals.

- E. Blade Action: Parallel.
- F. Blade Axles:
  - 1. Material: Aluminum.
  - 2. Diameter: 0.20 inch.
- G. Tie Bars and Brackets: Aluminum.
- H. Bearings: Synthetic pivot bushings.
- I. Accessories:
  - 1. Adjustment device to permit setting for varying differential static pressure.
  - 2. Counterweights and spring-assist kits for vertical airflow installations.
- J. Sleeve: Minimum 20-gage thickness.

## 2.03 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance Inc.; a division of Mestek, Inc.
    - b. American Warming and Ventilating; a division of Mestek, Inc.
    - c. Flexmaster U.S.A., Inc.
    - d. McGill AirFlow LLC.
    - e. METALAIR, Inc.
    - f. Nailor Industries Inc.
    - g. Ruskin Company.
    - h. Greenheck.
    - i. Vent Products Company, Inc.
    - j. United Enertech
    - k. Pottorff
    - l. NCA Mfg.
  - 2. Suitable for horizontal or vertical applications.
  - 3. Frames:
    - a. Hat-shaped, galvanized-steel channels, 16 ga. 0.064-inch minimum thickness.
    - b. Mitered and welded corners.
    - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
  - 4. Blades:
    - a. Multiple(min. 16 ga) or Single blade(min. 20 ga)
    - b. Parallel- or opposed-blade design.
    - c. Stiffen damper blades for stability.
    - d. Galvanized-steel

5. Blade Axles: Galvanized steel.
  - a. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
6. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
2. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 1/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include standoff bracket for insulated duct mounting.

D. Cable Operated Dampers

1. Provide cable operated dampers where indicated on drawings or where required to access volume dampers above inaccessible ceilings or behind walls.
2. Cable length as required for access via remote adjuster behind an adjustable cover plate for flush finish installation. Refer to A-series drawings for ceiling construction.
3. Cover plate primer coated cover for field painting unless noted otherwise.
4. Manufacturer of cable operated dampers systems: DuroDyne, Young Regulator, or approved equal.

## 2.04 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. Airstream
3. Arrow United Industries; a division of Mestek, Inc.
4. Cesco Products; a division of Mestek, Inc.
5. Greenheck Fan Corporation.
6. METALAIR, Inc.
7. Nailor Industries Inc.
8. American Warming & Ventilating.
9. Prefco; Perfect Air Control, Inc.
10. Ruskin Company.
11. Vent Products Company, Inc.
12. United Enertech
13. Pottorff
14. NCA Mfg.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.
- D. Fire Rating: 1-1/2 hours.
- E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - 1. Minimum Thickness: 14 gauge and of length to suit application.
  - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated fusible links.

## 2.05 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Air
  - 2. Air Balance Inc.; a division of Mestek, Inc.
  - 3. Cesco Products; a division of Mestek, Inc.
  - 4. Greenheck Fan Corporation.
  - 5. Nailor Industries Inc.
  - 6. NCA Manufacturing.
  - 7. Ruskin Company.
  - 8. United Enertech
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Smoke Detector: Integral, factory wired for single-point connection.
- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel.
- F. Leakage: Class II.
- G. Rated pressure and velocity to exceed design airflow conditions.

- H. Mounting Sleeve: Factory-installed, 14 gauge, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
- I. Damper Motors: Two-position action mounted out of air stream. Motors to be 120V, power open, spring closed design.
- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
  - 1. Motor Sizes: Large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections contained in these specifications.
  - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
  - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments.
  - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 20 deg F.
  - 6. Electrical Connection: 115 V, single phase, 60 Hz.
- K. Accessories:
  - 1. Auxiliary switches for signaling or position indication.
  - 2. Test and reset switches, damper mounted.

## 2.06 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Air
  - 2. Air Balance Inc.; a division of Mestek, Inc.
  - 3. Cesco Products; a division of Mestek, Inc.
  - 4. Greenheck Fan Corporation.
  - 5. Nailor Industries Inc.
  - 6. NCA Manufacturing.
  - 7. Ruskin Company.
  - 8. United Enertech
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 hours.
- E. Frame: Hat-shaped, 0.063-inch-thick, 16-gauge, galvanized sheet steel, with welded corners and mounting flange.
- F. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.

- G. Smoke Detector: Integral, factory wired for single-point connection.
- H. Blades: Roll-formed, horizontal, interlocking, 0.063-inch-thick, 16-gauge, galvanized sheet steel.
- I. Leakage: Class I.
- J. Rated pressure and velocity to exceed design airflow conditions.
- K. Mounting Sleeve: Factory-installed, 0.05-inch-thick, 18-gauge, galvanized sheet steel; length to suit wall or floor application.
- L. Master control panel for use in dynamic smoke-management systems.
- M. Damper Motors: Two-position action.
- N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices.
  - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
  - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
  - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
  - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
  - 7. Electrical Connection: 24 V, single phase, 60 Hz.
- O. Accessories:
  - 1. Auxiliary switches for signaling or position indication.
  - 2. Test and reset switches, damper mounted.

## 2.07 CONTROL DAMPERS

- A. Dampers – Insulated Air Foil(Required for Outside Air-Relief Air-Exhaust Air Systems)
  - 1. Damper construction: Incorporate blades equipped with steel shafts and operating in bearings in damper frame, arranged so that all linkages are encased in side channels of frame to decrease friction and eliminate noise.
  - 2. Frames: 16 gauge (minimum) galvanized steel or extruded aluminum.
  - 3. Blades: not exceeding 6" in width; air foil shaped, double thickness 22 gauge (minimum) galvanized steel with 1/2" polystyrene or polyurethane insulation.
  - 4. Bearing: Synthetic.

5. Seals: Installed on all blade edges and frame top and bottom stoops synthetic elastomer: Flexible spring stainless steel compression type for jamb seals.
6. Shafts: All shafts to be a minimum of 1/2" diameter. Actuator shaft shall be welded to the main control damper blade.
7. Insulated dampers shall be utilized for all outside air, relief air, and exhaust air services.
8. Damper Design: Class 1 leakage. 4,000 FPM maximum velocity, provide for tight shutoff, arranged so that leakage does not exceed 8 CFM/FT<sup>2</sup> at a 4" wg pressure differential. Designed for service of 180° F.
9. All dampers for modulating control: proportioning type with adjacent blades rotating in opposite directions. Note: Some proportional type dampers may require parallel rotation. Reference details on Drawings.
10. All dampers for two position action: have blades arranged for parallel rotation.
11. Manufacturers:
  - a. Greenheck ICD
  - b. Ruskin TED – 50
  - c. Tamco
  - d. United Enertech TB
  - e. Approved equal

B. Dampers – Air Foil(Required for Return Air Systems)

1. Damper construction: Incorporate blades equipped with steel shafts and operating in bearings in damper frame, arranged so that all linkages are encased in side channels of frame to decrease friction and eliminate noise.
  - a. Frames: 16 gauge (minimum) galvanized steel or extruded aluminum.
  - b. Blades: not exceeding 6" in width; air foil shaped, double thickness galvanized steel for 14 gauge equivalent thickness.
  - c. Bearing: Synthetic.
  - d. Seals: Installed on all blade edges and frame top and bottom stoops synthetic elastomer: Flexible spring stainless steel compression type for jamb seals.
  - e. Shafts: All shafts to be a minimum of 1/2" diameter. Actuator shaft shall be welded to the main control damper blade.
2. Damper Design: Class 1 leakage. 4,000 FPM maximum velocity, provide for tight shutoff, arranged so that leakage does not exceed 8 CFM/FT<sup>2</sup> at a 4" wg pressure differential. Designed for service of 180° F.
3. All dampers for modulating control: proportioning type with adjacent blades rotating in opposite directions. Note: Some proportional type dampers may require parallel rotation. Reference details on Drawings.
4. All dampers for two position action: have blades arranged for parallel rotation.
5. Manufacturers:
  - a. Greenheck VCD
  - b. Ruskin CD – 60
  - c. Tamco
  - d. Enertech
  - e. Approved equal

2.08 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Nexus PDQ; Division of Shilco Holdings Inc.
  - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.09 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate Industries, Inc.
  - 2. Duro Dyne Inc.
  - 3. METALAIRE, Inc.
  - 4. SEMCO Incorporated.
  - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.010 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a division of Mestek, Inc.
  - 2. Cesco Products; a division of Mestek, Inc.
  - 3. Ductmate Industries, Inc.
  - 4. Flexmaster U.S.A., Inc.
  - 5. Greenheck Fan Corporation.
  - 6. McGill AirFlow LLC.
  - 7. Nailor Industries Inc.
  - 8. Buensod Stacey Type F.
  - 9. Ventfabrics, Inc.
  - 10. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

11. Pottorff

- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

- a. Double wall, rectangular.
- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
- c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
- d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

- a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
- b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
- c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
- d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.011 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.
4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

- B. Materials: Flame-retardant or noncombustible fabrics.

- C. Coatings and Adhesives: Comply with UL 181, Class 1.

- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 20 to plus 200 deg F.

- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 20 to plus 250 deg F.

- F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
  2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

## 2.012 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wiremold Type 86-C.
  2. Aircon-Duct.
  3. Flexmaster U.S.A., Inc.
  4. McGill AirFlow LLC.
  5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 4-inch wg positive and 1-inch wg negative.
  2. Maximum Air Velocity: 4000 fpm.
  3. Temperature Range: Minus 20 to plus 175 deg F.
- C. Flexible Duct Connectors:
1. Clamps and Sheetmetal Screws: Nylon strap in sizes 3 through 18 inches with 3 sheetmetal screws to prevent blow-off of duct, to suit duct size.
  2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

## 2.013 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.014 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Commercial Acoustics.
  - 2. VAW.
  - 3. Ruskin Company.
  - 4. Vibro-Acoustics.
  - 5. Price Industries
- B. General Requirements:
  - 1. Factory fabricated.
  - 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
- C. Shape:
  - 1. As indicated on drawings.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, 22 gauge galvanized sheet steel.
- E. Inner Casing and Baffles: ASTM A 653/A 653M, G90, 26 gauge galvanized sheet metal with 1/8-inch- diameter perforations.
- F. Special Construction:
  - 1. High transmission loss to achieve STC 45.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
  - 1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
  - 2. Film-lined type with fill material.
    - a. Fill Material: Moisture-proof nonfibrous material.
    - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
  - 3. Lining: Mylar or Polyester.
- I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
  - 1. Continuously weld joints, flange connections.
  - 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
  - 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.
  2. Removable splitters.
- K. Source Quality Control: Test according to ASTM E 477.
1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
  2. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.
- L. Capacities and Characteristics:
1. As scheduled on drawings.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts and aluminum accessories in aluminum ducts.
- C. Install backdraft and/or control isolation dampers at outlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Install volume dampers at all locations as required for balancing whether shown or not. Dampers specified on backs of grilles shall not be used for balancing unless approved by Engineer.
  1. Install steel volume dampers in steel ducts.
  2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire, smoke, combination fire and smoke and ceiling radiation dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  1. On both sides of duct coils.
  2. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure

relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

3. At changes of direction of kitchen hood exhaust ducts.
  4. Elsewhere as indicated.
  - I. Install access doors with swing against duct static pressure.
  - J. Access Door Sizes:
    1. One-Hand or Inspection Access: 8 by 5 inches.
    2. Two-Hand Access: 12 by 6 inches.
    3. Head and Hand Access: 18 by 10 inches.
    4. Head and Shoulders Access: 21 by 14 inches.
    5. Body Access: 25 by 14 inches.
    6. Body plus Ladder Access: 25 by 17 inches.
    7. As Noted on Drawings
  - K. Label access doors according to Section 20 00 50.
  - L. Install flexible connectors to connect ducts to equipment.
  - M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
  - N. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct rated at 10" static, strapped in place with 3 sheet metal screw stop keep straps from blowing off ducts. Do not use flexible ducts to change directions.
  - O. Connect diffusers or light troffer boots to low-pressure ducts with maximum 36-inch lengths of flexible duct (rated at 4" static) strapped in place.
  - P. Connect flexible ducts to metal ducts with draw bands plus sheet metal screws.
  - Q. Install duct test holes where required for testing and balancing purposes.
- 3.02 FIELD QUALITY CONTROL
- A. Tests and Inspections:
    1. Operate dampers to verify full range of movement.
    2. Inspect locations of access doors and verify that purpose of access door can be performed.
    3. Operate fire, smoke and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
    4. Inspect turning vanes for proper and secure installation.
    5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

## SECTION 233416 – CENTRIFUGAL HVAC FANS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Backward-inclined centrifugal and plenum fans.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

### PART 2 - PRODUCTS

#### 2.01 BACKWARD-INCLINED CENTRIFUGAL AND PLENUM FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Barry Blower
  - 2. Chicago Blower Corporation
  - 3. Greenheck
  - 4. Loren Cook Company
  - 5. Twin City Fan

- B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Class III assembly construction.
- C. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
  - 1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - 2. Spun inlet cone with flange.
  - 3. Outlet flange.
  - 4. Factory finished with enamel paint
- D. Backward-Inclined Wheels: Single-width-single-inlet or double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded to flange and backplate and fastened to shaft with set screws.
- E. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - 1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
  - 2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- F. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  - 1. Ball-Bearing Rating Life: ABMA 9, L10 at 200,000 hours.
- G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - 1. Service Factor Based on Fan Motor Size: 1.5.
  - 2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - 3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - 4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
  - 5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  - 6. Motor Mount: Adjustable for belt tensioning.
- H. Accessories:
  - 1. As scheduled on the drawings.
  - 2. Fan guard
  - 3. Belt Guard
  - 4. Spring Isolators Specify 2"
- I. Motors: Comply with requirements in Division 20, Section 20 00 50.

1. Enclosure Type: Totally enclosed, fan cooled.

## 2.02 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install centrifugal fans level and plumb.
- B. Support floor-mounting units using concrete filled inertia bases having a static deflection of 2". Vibration- and seismic-control devices are specified in Division 20 Section 20 00 50.
  1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in "Cast-in-Place Concrete."
- D. Install units with clearances for service and maintenance.

### 3.02 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Ground equipment according to Division 26 Specifications.
- D. Connect wiring according to Division 26 Specifications.

### 3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  3. Verify that cleaning and adjusting are complete.
  4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  5. Adjust belt tension.
  6. Adjust damper linkages for proper damper operation.
  7. Verify lubrication for bearings and other moving parts.
  8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  9. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
  10. Remove and replace malfunctioning units and retest as specified above.
  11. Install inlet air sheet metal straightener as required if system experiences fan surge.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 16

## SECTION 233423 – HVAC POWER VENTILATORS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:

1. Centrifugal roof ventilators.
2. In-line mixed flow fans.
3. Motors.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- C. UL Standard: Power ventilators shall comply with UL 705.

### PART 2 - PRODUCTS

#### 2.01 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck.
  2. Loren Cook Company.
  3. Penn Ventilation.
  4. Twin City Fans.

- B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top or upblast arrangement with square, one-piece, aluminum base with venturi inlet cone.
  - 1. Hinged Sub-base: Galvanized-steel hinged arrangement permitting service and maintenance when scheduled on the Drawings.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
  - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
  - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  - 4. Fan and motor isolated from exhaust airstream.
  - 5. Belt tensioner.
- F. Accessories:
  - 1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
  - 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
  - 3. Dampers: parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - 4. Finish: Factory, Kynar paint, color to be dark bronze.
  - 5. As scheduled on the Drawings.
- G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
  - 1. Configuration: Built-in cant and mounting flange.
  - 2. Overall Height: 20 inches or as scheduled on the Drawings.
  - 3. Pitch Mounting: Manufacture curb for roof slope when required.
  - 4. Metal Liner: Galvanized steel.

## 2.02 IN-LINE MIXED FLOW FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Greenheck.
  - 2. Loren Cook Company.
  - 3. Penn Ventilation.
  - 4. Twin City Fans.
- B. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

- C. Housing: Square metal with inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, mixed flow blades welded to aluminum hub.
- F. Accessories:
  - 1. Backdraft damper in fan outlet.
  - 2. Companion Flanges: For inlet and outlet duct connections.
  - 3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
  - 4. Removable panels for access to internal parts.
  - 5. Factory wired disconnect switch located on outside of fan housing.
  - 6. As scheduled on the Drawings.

## 2.03 MOTORS

- A. Comply with requirements in Division 20, Section 20 00 50.
- B. Enclosure Type: Totally enclosed, fan cooled.
- C. Two Speed Motor

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
- C. Ceiling Units: Suspend units from structure; use all-thread rod or metal straps.
- D. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 20, Section 20 00 50.
- E. Install units with clearances for service and maintenance.
- F. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.
- G. Install ducts adjacent to power ventilators to allow service and maintenance.
- H. Ground equipment according to Division 26 Specifications.
- I. Connect wiring according to Division 26 Specifications.

### 3.02 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
  2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  3. Verify that cleaning and adjusting are complete.
  4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  5. Adjust belt tension.
  6. Adjust damper linkages for proper damper operation.
  7. Verify lubrication for bearings and other moving parts.
  8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  10. Shut unit down and reconnect automatic temperature-control operators.
  11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 23

## SECTION 233600 – AIR TERMINAL UNITS

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

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

#### 1.02 SUMMARY

- A. This Section includes the following:
  - 1. Variable Air Volume Box (VAV) with Hydronic Heating Coil.

#### 1.03 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:
  - 1. Instructions for resetting minimum and maximum air volumes.
  - 2. Instructions for adjusting software set points.

#### 1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.05 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.01 VARIABLE AIR VOLUME BOXES (VAV)

- A. For capacity and size see Equipment Schedule on drawings.
- B. Casing: 26 gauge dual wall galvanized steel. Provide factory installed dual wall access door in the bottom panel of each VAV box furnished with a heating coil.
- C. Insulation of terminal units shall be ½" thick, 1-1/2# density fiberglass between dual walls. Insulation must be UL approved and meet NBFU and NFPA 90A requirements.
- D. Control valve: shall seal against gasketed stops for minimum leakage. Maximum and minimum mechanical stops shall be provided. Total leakage of casing and valve shall not exceed 1% at 3" inlet static pressure.
- E. VAV Control Options:
  - 1. Air Flow Sensor: Integral multiple point air flow sensor to provide primary air flow within ±10% at 400 FPM air flow. Provide integral flow taps and calibration chart with each unit.
  - 2. Damper Actuator and Controller shall be provided by Temperature Control Contractor and installed by the VAV box manufacturer. Actuator shall provide tight close off to 100% open. Coordinate exact requirements with Temperature Control Contractor (TCC).
  - 3. Factory install controller as provided by and directed by TCC. Installation of TC's controller shall include, but not be limited to, mounting controller, damper actuator and pneumatic tubing to air flow sensor. Filter for pneumatic tubing will be provided by TCC.
  - 4. **Provide gauge taps for airflow measurement by test and balance contractor.**
  - 5. Cost to install control components shall be borne by VAV manufacturer.
  - 6. Reference Control Section for additional information.
- F. Hydronic Heating Coil: provide with hydronic coil with capacity as noted on drawings. Ends of coils shall be insulated. See Drawings for locations designated as cooling only.
- G. Manufacturers:
  - 1. Trane
  - 2. Titus
  - 3. Price
  - 4. Nailor Industries

2.02 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

- B. Verification of Performance: Rate air terminal units according to ARI 880.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

#### 3.02 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.
- C. Connect ducts to air terminal units according to other Division 23 Sections.
- D. Connect wiring according to Division 26 Specifications.

#### 3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

#### 3.04 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and do the following:
  - 1. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
  - 2. Verify that controls and control enclosure are accessible.
  - 3. Verify that control connections are complete.
  - 4. Verify that nameplate and identification tag are visible.
  - 5. Verify that controls respond to inputs as specified.

END OF SECTION 23 36 00

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## SECTION 233713 – DIFFUSERS, REGISTERS, GRILLES AND LOUVERS

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

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

#### 1.02 SUMMARY

- A. This Section includes ceiling-, floor- and wall-mounted diffusers, registers, and grilles.

This Section includes but is not limited to:

- 1. Ceiling Diffusers
- 2. Linear Bar Grilles
- 3. Grilles and Registers
- 4. Eggcrate Return Grilles

- B. Related Sections include the following:

- 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts. Coordinate with Architect as to whom is supplying grilles.
- 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

#### 1.03 SUBMITTALS

- A. Product Data: For each product indicated, include the following:
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

### PART 2 - PRODUCTS

#### 2.01 CEILING DIFFUSERS

- A. Round Ceiling Diffuser:
  - 1. Manufacturers:

- a. Price Industries
  - b. Titus TMRA
  - c. Nailor Industries
  - d. MetalAire
2. Material: Steel.
3. Finish: **[Baked enamel, white.] [Primer for field painting.]**
4. Face Style: **[Four cone] [Plaque].**
5. Mounting: Duct connection.
6. Pattern: Fully adjustable.
7. Dampers: upstream in ductwork.
8. Accessories:
  - a. Plaster ring (when applicable).
  - b. All back surfaces factory insulated with foil-backed insulation or molded insulation blanket.

B. Square Ceiling Diffusers:

1. Manufacturers:
  - a. Price Industries
  - b. Titus
  - c. Nailor Industries
  - d. MetalAire
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Size: As scheduled on the Drawings.
5. Face Style: **[Three cone] [Plaque].**
6. Mounting: Surface, T-bar, Snap in or Panel mounted. Reference Architectural drawings for ceiling type.
7. Pattern: Adjustable.
8. Dampers: upstream in ductwork.
9. Accessories:
  - a. Plaster ring (when applicable).
  - b. All back surfaces factory insulated with foil-backed insulation or molded insulation blanket.
10. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

2.02 LINEAR SLOT DIFFUSERS

A. Manufacturers:

1. Price Industries
2. Titus ML Series
3. Nailor Industries
4. MetalAire

- B. Material – Frame: Extruded aluminum.
- C. Material – Pattern Controller and Tees: Extruded aluminum.
- D. Finish – Frame and Tees: Baked enamel, white.
- E. Finish – Pattern Controller: Baked enamel, black.
- F. Slot Width: As noted on Schedule.
- G. Number of Slots: As noted on Schedule.
- H. Length: As noted on Schedule or Drawings.
- I. Mounting: T-bar or surface-mount. Provide appropriate end configuration and frame for application. Reference Architectural drawings for ceiling type.
- J. Accessories:
  - 1. Steel plenum with factory installed external insulation.
  - 2. Alignment strips (when required).

## 2.03 LINEAR BAR GRILLES

- A. Manufacturers:
  - 1. Price Industries
  - 2. Titus CT Series
  - 3. Nailor Industries
  - 4. MetalAire
- B. Material: Extruded aluminum
- C. Construction: Heavy duty construction for floor-mounted applications.
- D. Finish: Anodized aluminum, color selected by Architect.
- E. Size: Length and width as noted on Drawings.
- F. Core Spacing Arrangement, Mounting and Frame: As noted on Drawings.
- G. Damper Type: Adjustable opposed blade (where noted on Drawings).
- H. Accessories:
  - 1. Alignment strips (for lengths over 72").
  - 2. Blank-off strips (where noted on Drawings).

## 2.04 GRILLES AND REGISTERS

- A. Manufacturers:
  - 1. Price Industries
  - 2. Titus
  - 3. Nailor Industries
  - 4. MetalAire
- B. Capacity, size, and noise criteria as Scheduled(Return and Exhaust). Additional sizes may be required as indicated and noted on individual Drawings.
- C. Material: Heavy gauge steel or heavy gauge aluminum. Provide aluminum construction for installations in shower rooms and corrosive environments.
- D. Finish: Baked enamel, white (unless noted otherwise on Drawings).
- E. Mounting: Countersunk screws

- F. Frame: 1-1/4" wide.
- G. Metal plaster frames: for grilles mounted on plaster, masonry, fiber or metal construction surfaces.
- H. Volume Damper: Opposed blade operable through face of grille.
- I. Deflecting Blades: 3/4" spacing
- J. Supply Grilles: Similar to Titus 272 Series - airfoil blades, double deflection. Horizontal blades always mounted nearest grille face.
- K. Return Grilles: Similar to Titus 350 Series - single deflection blades fixed at 35°/45° down (unless noted otherwise on Drawings).
- L. Exhaust Grilles: Similar to Titus 350 Series - single deflection blades fixed at 35°/45° down.

## 2.05 EGGCRATE RETURN GRILLES

- A. Manufacturers:
  - 1. Price Industries
  - 2. Titus 50F
  - 3. Nailor Industries
  - 4. MetalAire
- B. Material: Aluminum
- C. Core Construction: 1/2" x 1/2" x 1/2" aluminum grid core.
- D. Finish: Baked enamel, white (unless noted otherwise on Drawings).
- E. Mounting: 1" inverted T-bar border for mounting in lay-in ceiling, 1-1/4 aluminum border with countersunk screwholes for surface mounting.
- F. Installation:
  - 1. Install internally lined acoustical boot on back of grilles unless noted otherwise.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final

locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel if not of panel dimension. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

### 3.03 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

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## SECTION 235700 – HVAC HEAT EXCHANGERS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes heat exchangers.
  - 1. Shell and Tube Heat Exchangers (STHX)

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Plate-removal space.
  - 2. Structural members to which heat exchangers will be attached.

#### 1.03 QUALITY ASSURANCE

- A. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

### PART 2 - PRODUCTS

#### 2.01 SHELL AND TUBE HEAT EXCHANGER

- A. Heat exchanger capacity, type, size, mounting arrangement, pressure drop and transfer fluids as shown on Drawings.
- B. Heat exchangers constructed in accordance with ASME and State of Indiana Rules and Regulations for Unfired Pressure Vessels as previously outlined.
- C. Shell to be constructed of carbon steel with welded seams and tapped for piping connections as shown. Tube sheet or sheets made of rolled steel with tubes rolled or expanded into sheet.
- D. Tubes, unless specifically noted otherwise,  $\frac{3}{4}$ " O.D., 18 gauge (BWG) seamless drawn copper.
- E. Head or heads cast iron and properly tapped and baffled for piping arrangement and number of passes shown.
- F. Exchangers suitable for 125 psig working pressure, tested for 200 psig. Furnish with cast iron mounting cradles and to be supported on suitable pipe or angle iron stand.
- G. Various types of exchangers noted on Drawings to be as hereinafter described.

H. U-Tube Type

1. Heating section constructed of U-bends of seamless copper tubing with both ends of tube expanded into same tube sheet. Tube sheet to be bolted between shell and head flanges and thereby provide removable tube bundle.
2. Steam supplied to shell and water to tube section. Steam baffles provided in shell to distribute steam evenly across tubes and prevent erosion by direct impingement on tubes as steam inlet.

I. Provide one (1) additional U-tube bundle assembly as part of this specification section.

J. Manufacturers:

1. Bell & Gossett
2. Armstrong

PART 3 - EXECUTION

3.01 HEAT-EXCHANGER INSTALLATION

- A. Install shell-and-tube heat exchangers on, and anchor to, concrete base. Provide all miscellaneous support steel.
- B. Install shell-and-tube heat exchangers on saddle supports.

3.02 CONNECTIONS

- A. Install shutoff valves at heat-exchanger inlet and outlet connections.
- B. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
- C. Install vacuum breaker at heat-exchanger steam inlet connection.
- D. Install hose end valve to drain shell.

END OF SECTION 23 57 00

## SECTION 237313 – MODULAR INDOOR CENTRAL-STATION AIR CONDITIONERS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. Section Includes:
  - 1. Modular central-station air-handling units.

#### 1.02 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

#### 1.03 SUBMITTALS

- A. Product Data: For each air-handling unit indicated.
  - 1. Unit dimensions and weight.
  - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
  - 3. Fans:
    - a. Certified fan-performance curves with system operating conditions indicated.
    - b. Certified fan-sound power ratings.
    - c. Fan construction and accessories.
    - d. Motor ratings, electrical characteristics, and motor accessories.
  - 4. Certified coil-performance ratings with system operating conditions indicated.
  - 5. Dampers, including housings, linkages, and operators.
  - 6. Filters with performance characteristics.
- B. Source quality-control reports.
- C. Operation and maintenance data.

#### 1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

- D. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.01 CENTRAL STATION AIR CONDITIONER (CSAC)

#### A. Unit Casing

1. Unit shall be constructed of a complete frame with removable panels. Removal of side panels must not affect the structural integrity of each module. The casing must be able to withstand up to six-inches positive or four-inches negative static pressure. All exterior wall panels shall be made of minimum 18 gauge G90 galvanized steel. Closed-cell foam gasketing shall be utilized where modules are joined. Unit casing shall be double-wall with smooth galvanized steel interior liner.
2. Units shall have an insulated, double wall stainless steel drain pan under cooling coil for drainage of condensate. Drain connections are to be provided on one side of the unit. Pans pitched to outlet.
3. Full sized, hinged, removable double-wall access doors with two step safety handles shall be provided for quick access to the interior of the unit casing. Doors attached by screws, or doors not continuously gasketed are not acceptable.

#### B. Dampers

1. All dampers to be high quality, air foil, constructed with all 6063T5 extruded aluminum including damper blades and damper frame.
2. Dampers to be Class 1A leakage rated.
3. All damper blades to air foil with neoprene damper edge seals.
4. Damper frame to have flexible metal compressible jamb seals.
5. Damper pivot shafts to be minimum 1/2" diameter that pivot in molded synthetic bearings mounted in damper frame.
6. All dampers that communicate directly with outside to have insulated blades.
7. Dampers to like Ruskin CD50 for non-insulated and Ruskin CD150 for insulated.
8. See drawings for damper orientation and location.

#### C. Insulation

1. Complete unit including fan, access, coil and filter sections shall be factory insulated with 2", 1-1/2 pound density insulation. All connecting channels shall be insulated to prevent sweating.

#### D. Filter Section

1. Filter media shall be a multi-layer 100% polyester fiber. The media shall contain a flame retardant binder as well as an anti-microbial agent that inhibits the growth of mold, mildew,

algae and bacteria. The agent shall be an integral part of the media and shall have both USDA and FDA approval.

E. Pre-filters

1. Pre-filters shall be 2" thick and be MERV-8 rated as determined by ASHRAE 52-76.

F. Final Filters

1. Final filters shall be 4" thick and be MERV-13 rated as determined by ASHRAE 52-76.
2. Pre-filters and final filters shall be secured so that filters are removed individually by a worker inside the unit from the upstream side (front loading). Or shall be changeable thru slide in-side access for smaller CSAC's.
3. Pre-filters and final filters shall be 24" x 24" or 24" x 12" face dimensions. Blank-off around filters shall be airtight. Include filter sizes in submittals.
4. Provide quantity of Filters as outlined in Section 20 00 10.

G. Filter Gage

1. Provide filter gage for measuring resistance to air flow through filters for each filter bank.
2. The gage shall be diaphragm actuated with pointer zero adjustment, signal flag, and 3-7/8" diameter white dial.
3. Filter gauge shall be mounted on unit housing at air filter bank approximately 5'-0" above finished floor.
4. Filter gage range shall be 0.0"-1.0" water like Dwyer Model 2001.

H. Motors

1. Motors shall be mounted integral to a spring isolated fan assembly furnished by the unit manufacturer. Motors shall be mounted inside the unit casing, and mounted on a slide base to permit adjustment of drive belt tension.
2. Motors shall be "T" frame. Reference Section 20 00 50 for motor specifications.
3. VFD rated.

I. Drives

1. Drives shall be fixed pitch.
2. Drives shall be selected at 1.5 service factor.
3. Plans show CFM at estimated static. Unit manufacturer shall provide sheaves for desired CFM at actual static as required at 100% motor RPM as directed by balance contractor.

J. Coils

1. Coil arrangement shall be as shown on drawings.
2. Reference Coils, Section 23 82 16, for coil specifications.

K. Fans

1. Fans shall be direct drive plug fan as scheduled on drawings.
2. Housed fan performance shall be certified as complying with ARI Standard 430-89. Centrifugal fans shall be dynamically balanced at the factory as a complete fan assembly (fan wheel, motor, drive). Fan shafts shall not exceed 75 percent of their first critical speed at any cataloged rpm.

3. Fans shall be equipped with self-aligning anti-friction pillow block bearings with a minimum life of L-50 200,000 hours. Bearings shall be equipped with grease lines allowing for lubrication from one side of the fan.
4. Fan and motor assembly shall be internally isolated from unit casing with spring isolators, furnished and installed by unit manufacturer. Fan scroll shall be attached to the unit casing by a flexible canvas duct.
5. Grease lines from both fan bearings shall be copper and be extended to the fan support bracket on the drive side adjacent to access door. Grease zerks shall be easily accessible when reaching through door. Getting into unit to grease bearings is not acceptable.
6. The drive side shall always be on same side as fan section access door.
7. The access door in the fan section shall have 10" square viewing port of double pane safety glass.

L. Access Doors

1. Provide access doors as shown on drawings.
2. Access doors shall be removable, hinged, fully gasketed, double wall construction similar to the module in which it is located.
3. Provide minimum 10" square viewing port of double pane safety glass in all access doors shown on drawings but of a minimum to look into the following access sections:
  - a. Fan Section
  - b. Downstream of Cooling Coil
4. Access doors shall comply with previously described leakage test when closed in the normal fashion.
5. Access doors shall open against the static pressure of the section in which it is located, i.e., open inward downstream of fan and open outward upstream of fan.
6. Step safety latches to be provided for doors that open with pressure.

M. Discharge Plenum - Provide discharge plenum where shown on drawings. Openings in plenum shall be provided in the field by the Sheet Metal Contractor.

N. Lights

1. Factory Mounted Marine Lights (enclosed and gasketed) shall be provided in all sections that have a viewing port and where indicated on drawings. Conduit, junction box, switch, globe, receptacle and bulb shall all be included. Devices shall be completely wired for one single point Electrical connection. All lights operable from a single pull switch mounted outside the unit.

O. Manufacturer of unit supplied other than first named shall verify unit will fit in allocated space.

P. Manufacturers

1. Carrier Corporation
2. Daikin Applied
3. Trane

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Equipment Mounting: Install air-handling units on concrete bases. Secure units to anchor bolts installed in concrete bases.
- B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- G. Install piping adjacent to air-handling unit to allow service and maintenance.
- H. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- I. Connect condensate drain pans and extend to nearest floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- J. Connect Hot- and Chilled-Water Piping per details on drawings.

END OF SECTION 23 73 13

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## SECTION 238134 – MINI-SPLIT AIR CONDITIONING

### PART 1 – GENERAL

#### 1.01 SYSTEM DESCRIPTION

- A. The variable capacity, mini (heat and cool model) split system shall be as specified.
- B. The outdoor unit shall be interconnected to indoor units and shall be of capacity as noted on Drawings. The indoor units shall be connected to the outdoor utilizing the manufacturer's specified piping joints and headers.
- C. Voltage Platform – as noted on Drawings.
- D. Simple Wiring – Systems shall use 16 AWG, 2 wire, multi-stranded, non-shielded and non-polarized daisy chain control wiring.
- E. Controls – Each device shall be provided with complete factory controls that communicate with each other. Coantractor shall be responsible for installation of all interlock communication wiring,

#### 1.02 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the cETL label.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.
- D. The outdoor unit will be factory charged with R-410A.

#### 1.03 WARRANTY

- A. The units shall have a manufacturer's warranty for a period of one (1) year from date of substantial completion. The compressors shall have a complete parts and labor warranty of six (6) years from date of substantial completion. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced. All warranty service work shall be performed by a factory trained service professional.

#### 1.04 OPERATING RANGE

- A. The operating range in cooling will be **-10°F DB ~ 110°F DB**.

## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Fujitsu Halcyon
- B. No approved equals.

### 2.02 OUTDOOR UNIT

- A. General: The outdoor unit is designed specifically for use as a complete system with indoor components.
  - 1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls.
  - 2. The sound pressure level standard shall be that value as listed at 3 feet from the front of the unit. The outdoor unit shall be capable of operating automatically at further reduced noise during night time.
  - 3. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
  - 4. The unit shall incorporate an auto-charging feature and a refrigerant charge check function.
  - 5. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
  - 6. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
  - 7. Provide all low ambient controls, baffles, and accessories as required to meet the required operational range.
- B. Unit Cabinet:
  - 1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-protected mild steel panels coated with a baked enamel finish.
- C. Compressor:
  - 1. The inverter scroll compressors shall be variable speed (PAM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
- D. Electrical:
  - 1. The power supply to the outdoor unit shall be as noted on Drawings.
  - 2. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded, stranded 2 conductor cable.
  - 3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.

## 2.03 MINI-SPLIT – FAN COILS

### A. Wall-Mounted Indoor Unit

1. General: Indoor unit shall be a wall-mounted unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space and have a finished white casing.
2. Indoor Unit:
  - a. Indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The drain pipe can be fitted to from the rear, top or left and right sides of the unit.
  - b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
  - c. Both refrigerant lines shall be insulated from the outdoor unit.
  - d. Return air shall be through a resin net mold resistant filter.
  - e. The indoor units shall be equipped with a condensate pan.
  - f. The indoor units shall be equipped with a return air thermistor.
3. Unit Cabinet:
  - a. The cabinet shall be affixed to a factory supplied wall hanging brackets and located in the conditioned space.
  - b. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
4. Coil:
  - a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
  - b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
  - c. The coil shall be a 2-row cross fin copper evaporator coil with 15 fpi design completely factory tested.
  - d. A thermistor will be located on the liquid and gas line.
  - e. A condensate pan shall be located in the unit.

### B. Ceiling Cassette Indoor Unit

1. General: Indoor unit shall be a wall-mounted unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space and have a finished white casing.
2. Indoor Unit:
  - a. Indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board,

- fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
  - b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
  - c. Both refrigerant lines shall be insulated from the outdoor unit.
  - d. Return air shall be through a resin net mold resistant filter.
  - e. The indoor units shall be equipped with a condensate pan.
  - f. The indoor units shall be equipped with a return air thermistor.
3. Unit Cabinet:
- a. The cabinet shall be affixed to a factory supplied wall hanging brackets and located in the conditioned space.
  - b. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
4. Coil:
- a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
  - b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
  - c. The coil shall be a 2-row cross fin copper evaporator coil with 15 fpi design completely factory tested.
  - d. A thermistor will be located on the liquid and gas line.
  - e. A condensate pan shall be located in the unit.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION REQUIREMENTS

- A. The system must be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.

#### 3.02 DEMONSTRATION/OWNER TRAINING

- A. The mini-split system manufacturer shall provide two (2) hours of on-site training to the Owner's maintenance personnel in the proper operation and care of the entire system.

END OF SECTION 23 81 34

## SECTION 238216 – AIR COILS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes air coils.

#### 1.02 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### PART 2 - PRODUCTS

#### 2.01 COILS

- A. General
  - 1. Coil capacities, size and number of rows as shown on Drawings. In no case shall coils be furnished with fewer rows of tubes than shown on Drawings.
  - 2. Coil connections for supply and return shall be clearly marked to ensure that direction of coil water flow is counter to direction of airflow.
  - 3. All coils shall be burst tested to 300 PSIG and proof tested under water to 200 PSIG unless otherwise noted.
  - 4. All hydronic coils shall have manual air vent and drain valve.
  - 5. Coils shall be extended surface type constructed of copper tubing not less than 5/8" O.D. with .025" wall.
  - 6. Fins fastened to tubes with sufficient pressure to insure permanent metallic bond or rolled into headers. Fins shall be uniformly spaced not closer than 1/8" center to center. Minimum Fin thickness .0095".
  - 7. Each cooling coil section mounted in 16 gauge, 304 stainless steel casing and each heating water coil mounted in 16 gauge galvanized steel casing with drilled mounting flange unless otherwise noted. Coils to have intermediate tube supports to prevent tube sagging.

8. Coils to be set and rigidly supported with angles and fastened to building or CSAC structure. Coils pitched for proper condensate or water drainage.
9. Internal spirals not used unless specifically noted on Drawings.
10. All coil performance shall be certified in accordance with AHRI Standard 410.
11. Coil connection nipples to coil headers to be red brass.

B. Hot Water and Chilled Water Coils

1. Standard serpentine type and pipe so entering water is connected to leaving air side of coil. Coils shall be ARI Certified.

C. Manufacturers – Same as manufacturer of equipment they are installed in or:

1. Carrier
2. Trane
3. Daikin
4. Temtrol
5. Haakon
6. Engineered Air
7. HeatCraft
8. Aerofin
9. Coilmaster Corp
10. Greenheck
11. Capitol Coil & Air

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Straighten bent fins on air coils.
- D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.
- E. Pipe coils as detailed on drawings.
- F. Install piping adjacent to coils to allow service and maintenance.
- G. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Division 23 Section "Instrumentation and Control for HVAC".
- H. Install ball valve with hose bib connection and cap to drain coils.

3.02 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 82 16

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## SECTION 238219 – FAN COIL UNIT

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes fan-coil units and accessories.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Wiring Diagrams: Power, signal, and control wiring. Wiring diagrams must match the equipment provided. Custom factory wiring such as terminal strip designations must be provided. Costs associated with field changes required if accurate wiring diagrams are not provided shall be borne by the equipment manufacturer.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### PART 2 - PRODUCTS

#### 2.01 FAN COIL (FC)

- A. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
- B. Capacity, voltage, mounting arrangement shown on Drawings.
- C. Ratings
  - 1. Air quantity, cooling capacity, heating capacity, coil pressure drop and electric power consumption ratings to be certified in accordance with ARI procedures and standards.
  - 2. Minimum capacities shall be maintained with maximum GPM noted on Drawings.
  - 3. All units listed by UL.
  - 4. Units to be quiet in operation.

D. Water Coils

1. Non-ferrous fins and tubes: tested at 250 psig. Mount coil to drain condensate without interrupting air flow. Firm fin to tube contact.
2. Coils to be easily removable by unscrewing pipe unions between coil and valves and pulling coil out front of unit. Holes in side sheets large enough to remove unions and air vent.
3. Provide air vent at top of coil.
4. Heating Coil. No chilled water coil.

E. Valves and Piping

1. See details on Drawings.

F. Drain Pan

1. Large enough to catch all condensate from coil, return bends and valves at coil header.
2. Constructed with smooth inside surface of stainless steel or preformed plastic, externally insulated (not to sweat), pitched for complete drainage. Drain connection shall be at side of pan. Invert of drain pipe shall be below bottom of pan. All four corners of metal drain pan shall be welded for water tight seal. No folding of pan to form corners allowed. No standing condensate allowed in pan.
3. Air vent to be located above drain pan and faced to be operated manually from side of unit.
4. Provide drain pan extension of size that will completely cover area below strainers, valves and fittings to catch all condensate from trim.
5. Include water level detection device conforming to UL 508 that will shut off the fan coil unit in the event that the primary drain is unable to remove the condensate from the pan.

G. Fans

1. Double inlet squirrel cage, statically and dynamically balanced. Fan wheel and scroll to be corrosion resistant.
2. Fan mounting deck, fans and motor removable for servicing with plug-in electrical connection. Fan deck to be removable without use of special tools. Fastening devices shall be accessible by hand.

H. Motor Controllers

1. Three speeds and off, mounted to or inside cabinet housing.
2. Motors shall be ECM type. Speed control by T.C.C. Coordinate all interface requirements.

I. Electrical

1. Factory installed and wired fused disconnect switch, mounted to or inside cabinet housing.
2. Provide 24V control transformer for use by Temperature Controls Contractor.

J. Filters

1. Units shall be supplied with filters.
2. Furnish with 1" thick filters with a MERV-5 rating, total 3 sets.

K. Unit Enclosure

1. Units' arrangement and style shall be as scheduled on the drawings.
2. Enclosure shall have flange for supply and return duct connections.
3. Enclosure shall not have openings between filter and coils.
4. Insulation: fan and cold air plenum, and enclosure to be internally insulated with flexible elastomeric insulation to eliminate sweating and reduce airborne noise generated by fans.
5. Cabinet enclosure constructed of 16 gauge steel and exposed cabinets constructed of 14 gauge steel.
6. Provide access door safety chains on horizontal exposed units.

L. Manufacturers:

1. International
2. Trane
3. Daikin
4. Zehnder Rittling

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Install fan-coil units to comply with NFPA 90A.
- B. Suspend fan-coil units from structure with elastomeric hangers.
- C. Install new filters in each fan-coil unit within two weeks after Substantial Completion.
- D. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  1. Install piping adjacent to machine to allow service and maintenance.
- E. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.

#### 3.02 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 82 19

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## SECTION 238233 – CONVECTORS & FINNED-TUBE RADIATION - HYDRONIC

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Hydronic finned-tube radiation.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

### PART 2 - PRODUCTS

#### 2.01 FINNED TUBE RADIATION

- A. Finned tube element and enclosure shall be of capacity, heating medium, mounting arrangement and length as shown on Drawings.
- B. Heating Elements: fin and tube materials as noted on Drawings and conforming to the following:
  - 1. Copper tubing: minimum wall thickness, 1" tube .035", 1-1/4" tube - .042". Tube ends to fit standard sweat fittings.
  - 2. Aluminum fins: fin thickness and spacing as noted on Drawings. Fins shall be mechanically or hydraulically bonded to tube within fin collar. Fin thickness and spacing as noted on Drawings.
  - 3. Heating elements to be furnished by enclosure manufacturer, except where special enclosures are specified from manufacturers who do not manufacture heating elements. In this latter case, elements shall be: Trane; Sterling; Vulcan; Modine; Rittling; Slant/Fin.
- C. Element Accessories:
  - 1. Fin Pipe Hangers: Wall mounted: two piece cradle to give unrestricted lengthwise movement. Space to support element without sagging (not more than 4' on center.)

2. Install radiation type Expansion Compensator for each straight run of fin pipe over 25' in length. Flexonics Model T, Metro-Flex Model TP.
- D. Enclosure Types: finned tube radiation enclosures shall be of height and style as noted on Drawings and conform to the following:
1. Standard Enclosure
    - a. Enclosure constructed of 14 gauge furniture steel.
    - b. All standard enclosure styles to have open bottom inlet and extruded aluminum discharge grilles.
    - c. Enclosure support styles shall be pedestal or continuous, gasketed concealed, top support strip-mounted tightly to wall. Plus intermittent steel enclosure support brackets mounted on maximum of 4' on center.
    - d. Finish in baked enamel finish in one of manufacturer's standard colors, as selected by Architect. Submit color chart with Drawings for approval.
  2. Enclosure Accessories
    - a. Enclosure butt joints: end of one enclosure piece recessed to receive straight end of second enclosure piece to make smooth, flush, finished cabinet. No overlapping batten strips allowed.
    - b. Corner Trim Pieces: where Drawings show enclosure to be continuous around walls, corners, columns, pilasters, etc., install full enclosure height inside and outside corner pieces to match straight run enclosure.
    - c. End pieces: where Drawings show enclosures to be continuous from wall to wall, or partition to partition, straight run enclosures to be carefully butted to wall or partition with open ends. Where enclosure is not wall to wall, install end closure pieces at end of cabinet.
    - d. Wall-to-wall enclosures: install removable trim strips (full height of enclosure) at each shutoff valve, balancing valve, air vent, steam trap and expansion compensator.
    - e. Enclosures with end pieces: install integral, flush, hinged, access door at each end of enclosure. Door to be secured with screwdriver operated cam lock.
    - f. Extruded aluminum grille.
- E. Manufacturers
1. Trane
  2. Sterling
  3. Vulcan
  4. Modine
  5. Zhender Rittling
  6. Sigma Products

### PART 3 - EXECUTION

#### 3.01 FINNED-TUBE RADIATOR INSTALLATION

- A. Install units level and plumb.

- B. Install finned-tube radiators according to manufacturer's instructions.
- C. Install enclosure continuously around corners, using outside and inside corner fittings.
- D. Join sections with splice plates and filler pieces to provide continuous enclosure.
- E. Install access doors for access to valves.
- F. Install enclosure continuously from wall to wall.
- G. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
- H. Install valves within reach of access door provided in enclosure.
- I. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
- J. Install piping within pedestals for freestanding units.

### 3.02 CONNECTIONS

- A. Connect hot-water units and components to piping as detailed on drawings.
  - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- B. Install control valves as required as indicated on drawings.
- C. Install piping adjacent to convection heating units to allow service and maintenance.

### 3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION 23 82 33

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## SECTION 238239 – UNIT HEATER

### PART 1 – GENERAL

#### 1.01 SUMMARY

A. Section Includes:

1. Cabinet unit heaters with centrifugal fans and hot-water coils.
2. Propeller unit heaters with hot water coils.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Plans, elevations, sections, and details.
  2. Location and size of each field connection.
  3. Equipment schedules to include rated capacities, furnished specialties, and accessories.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### PART 2 - PRODUCTS

#### 2.01 CABINET UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Sterling
  2. Engineered Air Ltd.
  3. Modine
  4. Zhender Rittling
  5. Trane.

- B. Description: A factory-assembled and -tested unit complying with ARI 440.
  - 1. Comply with UL 2021.
- C. Coil Section Insulation: Flexible elastomeric insulation.
  - 1. Thickness: 1/2 inch.
  - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
  - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
- D. Cabinet: Steel with baked enamel finish with manufacturer's standard paint, in color selected by Architect.
  - 1. Vertical Unit, Exposed Front Panels: Minimum 14 gauge sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
  - 2. Horizontal Unit, Exposed Bottom Panels: Minimum 14 gauge sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
  - 3. Recessing Flanges: Steel, finished to match cabinet.
- E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - 1. Glass Fiber Treated with Adhesive: Minimum MERV 4.
- F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- G. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 20, Section 20 00 50.
  - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- H. Electrical Connection: Factory wire motors, controls and unit mounted fused disconnect switch for a single field connection. Voltage as scheduled on the Drawings.
- I. Capacities, Characteristics and Arrangement:
  - 1. As scheduled on the Drawings.

## 2.02 PROPELLER UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Engineered Air Ltd.

2. Modine.
  3. Zhender Rittling.
  4. Sterling.
  5. Trane.
- B. Description: An assembly including casing, coil, fan, and motor in discharge configuration scheduled on the Drawings.
- C. Comply with UL 2021.
- D. Cabinet: Removable Panels for maintenance access to controls.
- E. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
- F. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.
- G. Hot Water Coil: Test and rate hot water propeller unit heater coils according to ASHRAE 33. Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.
- H. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- I. Fan Motors: Comply with requirements in Division 20, Section 20 00 50.
1. Motor Type: Permanently lubricated. Voltage as scheduled on the Drawings.
  2. Factory installed and wired fused disconnect switch.
- J. Electrical Connection: Factory wire motors, controls and unit mounted fused disconnect switch for a single field connection. Voltage as scheduled on the Drawings.
- K. Capacities, Characteristics and Arrangement:
1. As scheduled on the Drawings.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install unit heaters to comply with NFPA 90A.
- B. Suspend cabinet unit heaters from structure with elastomeric hangers and vibrations isolators. Vibration isolators are specified in Division 20, Section 20 00 50.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods.
- D. Install new filters in each unit before starting supply fans.

- E. Piping installation requirements are specified in other Division 20 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- F. Install piping adjacent to machine to allow service and maintenance.
- G. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors.
- H. Comply with safety requirements in UL 1995.
- I. Ground equipment according to Division 26 Specifications.
- J. Connect wiring according to Division 26 Specifications.

### 3.02 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 82 39

## SECTION 238243 – RADIANT CEILING PANELS - HYDRONIC

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes the following:
  - 1. Radiant Ceiling Panels - Hydronic.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Include a schedule showing unique model designation, room location, model number, size and accessories furnished.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Product Options: Drawings indicating size, profiles and dimensional requirements of radiant panels are based on the specific system indicated.

#### 1.04 COORDINATION

- A. Coordinate layout and installation of radiant panels and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system and partition assemblies.

### PART 2 - PRODUCTS

#### 2.01 RADIANT CEILING PANELS - HYDRONIC

- A. Linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.

- B. Water Tubes: Tubes shall consist of seamless ½" nominal (5/8" OD) copper tubing. ½" nominal (5/8" OD) return bends and interconnectors shall be flared ends and be shipped loose. Water connections shall be suitable for solder, compression fittings or threaded connection.
- C. Heat Sinks: Heat sinks shall be extruded aluminum and copper piping will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
- D. Extruded Aluminum Planks: The panel shall be constructed of 0.0725" thick minimum extruded aluminum. The extruded aluminum panels shall interlock using tongue and groove connections and be mechanically held together.
- E. Insulation: All active panels shall be insulated with 1" thick, ¾ lb. density fiberglass insulation.
- F. Dimensions: Panel lengths and widths as indicated on the drawings. Total width and number of tubes should meet the required design specifications.
- G. Capacity: As scheduled. Linear radiant panel capacity shall be tested and certified by manufacturer to meet performance listed on the schedule.
- H. Finish: All visible components shall be powder-coated with polyester paint. Color to be manufacturer's standard white unless noted otherwise. Panel manufacturer to provide all T-bar trim framing for installations in hard ceilings or bulkheads. Division 23 contractor shall be responsible for the coordination of the installation.
- I. Mounting: Radiant panels shall be mounted in lay-in or drywall ceiling. Manufacturer shall provide all required hardware for suspension support system.
- J. Manufacturers
  - 1. Sterling
  - 2. Price
  - 3. Airtex
  - 4. Vulcan
  - 5. Zhender Rittling

## PART 3 - EXECUTION

### 3.01 INSTALLATION - GENERAL

- A. Install radiant panels level and plumb. Maintain sufficient clearance for normal services, maintenance or in accordance with construction drawings.
- B. Install radiant panels according to manufacturer's instructions.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - 1. Verify that controls and control enclosure are accessible
  - 2. Verify that control connections are complete to control valves as needed.
  - 3. Verify that any identification tags are visible.

4. Verify that controls respond to inputs as specified.

### 3.02 CONNECTIONS

- A. Connect radiant panels and components to piping as detailed on drawings.
  1. Install shutoff valves and unions on inlet and outlet, strainer on inlet and balancing valve on outlet.
- B. Install control valves as indicated on drawings.
- C. Install piping adjacent to radiant panels to allow for service and maintenance.

### 3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  1. Leak Test: After installation, fill water tubes and test for leaks. Repair leaks and retest until no leaks exist.
  2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
  3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

### 3.04 CLEANING AND PROTECTION

- A. Clean all visible surfaces of equipment; touch up as required.
- B. Protect all units before, during and after installation. Damaged materials due to improper protection shall be cause for rejection.

END OF SECTION 23 82 43

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## SECTION 238413 - HUMIDIFIERS

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section includes duct mounted steam humidifiers.

#### 1.02 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
  - 1. Include wiring diagrams.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

#### 1.03 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

### PART 2 - PRODUCTS

#### 2.01 DUCT MOUNTED HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong International, Inc.
  - 2. Dri-Steem.

### PART 3 - Steam Humidifiers for electric modulating control

- A. Humidifier shall be the steam separator type providing full separation ahead of an integral steam jacketed control valve which discharges through an internal steam jacketed drying chamber, a silencing chamber, and a steam jacketed distribution manifold.

- B. Humidifier shall receive steam at supply pressure and discharge at atmospheric pressure. It shall be furnished with inlet strainer and external inverted bucket steam trap.
- C. Separating chamber shall be of a volume and design that will disengage and remove all water droplets and all particulate matter larger than 3 microns when humidifier is operating at maximum capacity.
- D. The stainless steel metering valve shall be integral within the body of the humidifier, and shall be jacketed by steam at supply pressure and temperature to prevent condensation.
- E. The internal drying chamber shall receive steam at essentially atmospheric pressure and be jacketed by steam at supply pressure and utilize a stainless steel silencing medium.
- F. The distribution manifold shall provide uniform distribution over its entire length and be jacketed by steam to assure that vapor discharged is free of water droplets.
- G. Humidifier shall be equipped with an interlocked temperature switch to prevent the humidifier from operating before start-up condensate is drained.
- H. Accessories:
  - 1. Humidistat: Provided by Temperature Control Contractor.
  - 2. Duct-mounting, high-limit humidistat.
- I. Capacities and Characteristics:
  - 1. As scheduled on the Drawings

#### PART 4 - EXECUTION

##### 4.01 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance.
- B. Seal humidifier manifold duct or plenum penetrations with flange.
- C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install stainless-steel drain pan under each manifold mounted in duct.
  - 1. Construct drain pans to comply with ASHRAE 62.
  - 2. Connect to condensate trap and drainage piping.
  - 3. Extend drain pan upstream and downstream from manifold a minimum of 24 inches or as recommended by manufacturer.
- E. Install manifold supply piping pitched to drain condensate back to humidifier. Manifold supply piping material shall be as suggested by manufacturer. Systems utilizing a reverse osmosis

system shall utilize .065" wall stainless steel piping between humidifier and dispersion tubes or as recommended by unit manufacturer.

- F. Install drip leg upstream from steam trap a minimum of 12 inches tall for proper operation of trap.
- G. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 1. Install piping adjacent to humidifiers to allow service and maintenance.
  - 2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- H. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
- I. Install piping from safety relief valves to nearest floor drain.
- J. Connect wiring according to Division 26 Specifications.

#### 4.02 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

#### 4.03 TRAINING AND DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Division 01 Section "Demonstration and Training."
- B. Provide two (2) hours of Owner training.

END OF SECTION 23 84 13

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## SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General, Supplementary, and Special Conditions apply to all electrical work.

#### 1.02 DESCRIPTION OF WORK

- A. Section 260500 applies to all electrical materials, equipment, installations and services supplied under any portion of the work.
- B. All work must meet or exceed all Local, State and Federal Codes and ADA Guidelines.
- C. All Electrical Contractor or Electrical Sub-contractor work shall be performed by a licensed and bonded Electrical Contractor with at least five (5) years of successful installation experience on projects with electrical work similar to this project.
- D. The Electrical Contractor or Electrical Sub-contractor shall coordinate the Basic Requirements as applicable to any equipment, installations and services of an electrical nature.
- E. It is the intention of this Division of the Specifications and the accompanying drawings to describe and provide for the furnishing, installing, testing and placing in satisfactory and successful operation all equipment, materials, devices and necessary appurtenances to provide a complete electrical system.
- F. The Contract drawings indicate the extent and the general location and arrangement of equipment, conduit and wiring. The General Contractor and their Electrical Sub-contractor shall study the plans and details and shall coordinate with all other trades to prevent conflict and interference with other installations.
- G. The Electrical Contractor or the Electrical Sub-contractor is responsible for installation of a complete and operating electrical system in accordance with the intent of the Drawings and Specifications.
- H. Any minor changes in location of equipment and conduits from those shown on the plans shall be made without extra charge if so directed by the Owner prior to installation.
- I. All equipment shall be installed such that maintenance and service may be properly accomplished. If necessary, the Owner may at their option require the contractor to demonstrate the service on any piece of equipment to determine sufficient service space exists. If service space is not adequate, the equipment shall be relocated at no additional cost to the Owner so that sufficient service space is achieved.

#### 1.03 PERMITS AND FEES

- A. This work shall include the procurement of and payment for all permits and fees for the performance of the electrical work.

#### 1.04 SUBMITTALS

- A. The following items that shall be submitted for approval prior to ordering. Submit individually by the appropriate Specification Section number.
  - 1. Raceway (unless special raceway is specified a letter on Company letterhead stating the products to be used are in conformance with the Specifications is acceptable as a Submittal. Check with Engineer/Owner)
  - 2. Wire (unless special wire is specified a letter on Company letterhead stating the products to be used are in conformance with the Specifications is acceptable as a Submittal. Check with Engineer/Owner)
  - 3. Wiring Devices and Covers
  - 4. Lighting Fixtures
  - 5. Disconnect Switches
  - 6. Motor Starters
  - 7. Panelboards and Switchboards
  - 8. Fire Alarm
  - 9. Others as required by the related Division 26 Section.
- B. Submission of the above information shall be electronically in ISU approved PDF Format.

#### 1.05 PROJECT CLOSEOUT

- A. On Electrical Prime Projects one set of all Project documents shall be submitted electronically in PDF Format on a CD or DVD. The following is a list, but not limited to, of required documentation to be included on the CD or DVD:
  - 1. Bid Form
  - 2. Award Letter and Contract for Construction
  - 3. Meeting minutes and supporting documentation.
  - 4. Reviewed submittals and reviewed shop drawings
  - 5. All Change documentation, e.g. ASI, RFI, CCD, RFP, CP, CO, etc.
  - 6. Pay Applications
  - 7. Installation instructions and schematic drawings
    - a. Complete parts list with manufacturer's model numbers.
    - b. Complete wiring diagrams showing all connections and internal wiring. Factory typical wiring diagrams are not acceptable.
  - 8. Operating and maintenance instructions.
  - 9. Warranty and guarantee information
  - 10. Substantial Completion documents to determine start of Warranty Period
- B. Additionally submit one hard copy of the O&M's in a 3-ring binder and unfolded Record Drawings.

- C. Prior to release of final payment, Indiana State University must receive a complete set of record drawings in AutoCAD 2010 on a CD or DVD. The Design Engineer and the Indiana State University Department of Facilities Management engineering staff must approve these drawings.

#### 1.06 COPPER REQUIREMENTS FOR ELECTRICAL EQUIPMENT

- A. All current-carrying components (phase, neutral and ground) of all electrical equipment shall be copper. No CUAL allowed without prior approval of Owner.
- B. Exceptions: molded case circuit breakers with in-built lugs and safety switches.

#### 1.07 UNDERGROUND UTILITIES

- A. All underground utility lines shall be buried a minimum of 36" below finished grade.
- B. Place 3" of compacted red sand below all buried utility lines and cover with 12" of red sand.
- C. Remainder of the trench shall be back filled with new topsoil free of debris, compacted in 6" lifts to 98% standard proctor using the water jet method.
- D. Install the appropriate 6" wide marker tape a minimum of 12" above any buried utility line.

#### 1.08 NEUTRAL RULES

- A. Neutral rules and requirements for multi-circuit branch raceway installations.
  - 1. A separate dedicated neutral shall be installed for every phase conductor in a multi-circuit 120-volt or 277-volt raceway.
  - 2. Neutrals shall be marked in such a way as to prevent the accidental crossing of neutrals at device locations.
  - 3. Neutrals in 120-volt applications shall be white, gray in 277-volt applications.
  - 4. This includes pre-wired raceway systems such as ISODUCT and systems furniture.
  - 5. No sharing of neutrals is allowed.
- B. Over sizing of neutral conductors shall not be allowed in lieu of the preceding rules and requirements.
- C. THESE RULES SUPERCEDE ANY OTHER NEUTRAL INSTRUCTIONS EITHER WRITTEN OR IMPLIED IN ANY OTHER SPECIFICATION SECTION OR SHOWN ON DRAWINGS.

#### 1.09 RACEWAY SYSTEMS INSTALLATION SUMMARY

- A. Provide conduits, cable trays, surface raceways, boxes, fittings and supports to form a complete, coordinated, and continuously grounded raceway system.
- B. No more than three (3) single phase (120volt and 277volt) circuits shall be installed in a conduit raceway system..

#### 1.10 RACEWAY REQUIREMENTS

- A. Conduits indoors in general areas shall be electrical metallic tubing (EMT) with steel set screw or compression fittings.
- B. Conduits indoors in hazardous areas, encased in concrete floor slabs or subjected to water, physical damage or abuse shall be galvanized rigid steel (GRS) or intermediate metal conduit (IMC) with cast or malleable iron threaded fittings and bushings.
- C. Conduits indoors for medium voltage distribution circuits or for fire pump feeders shall be galvanized rigid steel conduit with cast or malleable iron threaded fittings and bushings.

- D. Conduits outdoors shall be galvanized rigid steel or intermediate metal conduit with cast or malleable iron threaded fittings and bushings.
- E. Conduits encased in concrete underground shall be Type DB PVC for IT applications and Schedule 80 for MV applications both with matching fittings.
- F. Conduits direct buried underground shall be Schedule 40 PVC with matching fittings.
- G. Conduits in steam tunnels shall be galvanized rigid steel or intermediate metal conduit with cast or malleable iron threaded fittings and bushings. Exceptions to this requirement are tunnel segments inside building (i.e., mechanical rooms) where EMT may be used.
- H. Final connections to recessed lighting fixtures and under counter lights shall be 1/2" minimum flexible metallic conduit, manufactured wiring systems, or galvanized steel Type MC Cable all with steel fittings.
  - 1. Manufactured wiring systems shall
    - a. Only be used above accessible ceilings.
    - b. Shall not be used in walls or above permanent ceilings.
    - c. Shall contain a dedicated, separate, grounding conductor.
  - 2. Type MC cable conductors shall be color coded to match the building color-coding scheme. Type MC Cable shall be terminated with steel setscrew connectors that have integral insulating bushings. Self-locking, twist-in type fittings are not acceptable.
- I. Final connections to motors, transformers and equipment subject to vibration or removal for maintenance shall be 1/2" minimum liquid tight flexible metallic conduit with steel liquid tight fittings. Transformer connections may be non-liquid tight flexible metallic conduit in electrical rooms only.
- J. Connections to recessed power receptacles and light switches in areas with accessible ceilings:
  - 1. In new 'metal stud and gypsum board partitions (walls)' and in existing 'metal stud and gypsum board partitions (walls)', where the wall is not being otherwise opened up, the final connections may be made with type MC Cable. This MC Cable, shall:
    - a. Be run to a box immediately above the accessible ceiling, and the box size shall not exceed 4-11/16" square.
    - b. Conduit shall be used for the entire run, from this junction box, to the power source, load (lights), etc.
    - c. No more than three circuits may be run through any given junction box.
    - d. Individual conductors making up the MC cable shall be stranded copper, with separate grounding conductor, and steel corrugated armor. Individual conductors shall be color coded as required in section 16120.
    - e. The MC Cable is terminated using UL listed hardware intended for the cable and boxes being used, (and rated for commercial and industrial environments).
    - f. The MC Cable shall be secured in the wall cavity as required by NEC.
    - g. The MC Cable shall be as short as it is necessary to serve the need and meet the Code
- K. In areas with non-accessible ceilings devices shall be installed with standard conduit; run back in a continuous installation to a junction box located at an access point in the ceiling

- L. Connections to other recessed devices, (including communication outlet boxes, junction or pull boxes, etc) shall be with standard conduit of the type appropriate for the wall construction.

#### 1.11 CABLE TRAY REQUIREMENTS

- A. Power and telecommunications cable trays shall be aluminum, ladder type, of the sizes shown on the drawings.
- B. Center spline telecommunications cable tray may only be used where shown.
- C. Changes in cable tray direction or elevation shall be made using standard fittings from the same manufacturer as the cable tray.
- D. Barriers shall be installed in cable trays where shown to separate circuits of different voltage levels.

#### 1.12 SURFACE RACEWAY REQUIREMENTS

- A. When conduits in finished areas cannot be concealed in walls or above ceilings, surface raceways may be used where permitted. Boxes and fittings shall match and be from the same manufacturer as the raceways.
- B. Raceway shall be metal and white in color unless otherwise noted on the drawings.
- C. Contractor shall verify with the Owner if the use of metal surface raceway is acceptable.

#### 1.13 BOX REQUIREMENTS

- A. Provide sheet steel outlet boxes, extensions, and plaster rings for EMT, flexible metal conduit, and MC cable.
- B. Provide cast or malleable iron outlet boxes and covers for galvanized rigid steel conduits, intermediate metal conduits, and liquidtight flexible metal conduits.
- C. Boxes shall be sized for all conductors and devices to be contained within. Box extensions shall not be used to correct for undersized boxes. A single extension may be used as follows only if all free conductors extend at least 3 inches outside of the extension opening.
  - 1. On boxes being flush mounted in masonry walls.
  - 2. On existing boxes in walls that are being furred out.
  - 3. On existing boxes for connecting to an existing circuit.
  - 4. On fire alarm, security and clock system boxes where required by the system manufacturer's instructions.
- D. Plaster rings shall not be considered box extensions, but their capacities may be included in box fill calculations.

#### 1.14 SUPPORT REQUIREMENTS

- A. Mechanical Areas and Tunnels
  - 1. Surface mounted equipment shall be secured to steel channels.
  - 2. Surface mounted raceway 1½" and smaller and boxes maybe attached directly to surfaces.
  - 3. Multiple raceway runs maybe attached to
    - a. A trapeze system with approved straps

- b. Trapeze shall be attached to the structure by steel channels and threaded rod.
  - 4. Vertical surface race way 1½" maybe attached by:
    - a. Below 8' by one or two hole straps
    - b. 8" and above with pipe hangers ("Minerallac style hangers")
  - 5. The channels and raceway shall be attached with toggle bolts to hollow tile, block or similar surfaces, and attached with screws or bolts and expansion shields to solid masonry or concrete.
- B. Finished Areas Above Suspended Ceilings
  - 1. Raceway and boxes maybe attached directly to surfaces with appropriate straps or hangers.
  - 2. Multiple raceway runs maybe attached to
    - a. A trapeze system with approved straps
    - b. Trapeze shall be attached to the structure by steel channels and threaded rod.
  - 3. The channels and raceway shall be attached with toggle bolts to hollow tile, block or similar surfaces, and attached with screws or bolts and expansion shields to solid masonry or concrete.
  - 4. Attachment of raceway to ceiling grid support wires or rods is not permitted.
- C. Finished Areas Inside Walls
  - 1. Raceway and boxes shall be attached to structural members with devices specifically designed for raceway/box attachment to the type of structural member used.
- D. Finished Areas Exposed
  - 1. Surface raceway shall be attached to finished surfaces utilizing the factory approved method of attachment.
  - 2. Tape is not acceptable for attachment of non-metallic surface raceway.

## PART 2 - PRODUCTS

### 2.01 CONDUITS

- A. Electrical metallic tubing shall be thin wall steel tubing, electro-galvanized or hot dipped galvanized inside and outside. Fittings and bushings shall be galvanized steel set screw type with two screws per connection for sizes over 2".
- B. Galvanized rigid steel conduit and intermediate metal conduit shall be hot dipped galvanized inside and outside, in 10' lengths and threaded on both ends. Fittings and bushings shall be cast or malleable iron, and hot dipped galvanized inside and outside.
- C. PVC conduit and fittings shall be Type DB for encasement in concrete for IT applications, Schedule 40 for direct burial, concealed and exposed work, and Schedule 80 in MV Duct Banks. Fittings shall be of the same type and from the same manufacturer as the conduit. PVC conduit shall be UL Labeled for 90 degrees C cables. Approved Manufacturers:
  - 1. Cantex
  - 2. Carlon
  - 3. National Pipe & Plastic.

- D. Flexible metallic conduit shall be galvanized steel or aluminum. Fittings shall be of steel with cadmium or galvanized finish. Fittings shall be machine screw clamp type, single or two-piece. Self-locking, twist-in type fittings are not acceptable.
- E. Liquid tight flexible metallic conduit shall consist of a flexible, galvanized steel core, a continuous copper ground strip and a polyvinyl chloride jacket. Fittings shall be steel liquid tight grounding type from the same manufacturer as the conduit.

## 2.02 CABLE TRAYS

- A. Ladder type cable tray shall be aluminum, of the width shown, with 4" rail height, 13/16" minimum rung width, and 9" maximum rung spacing. The tray with a 10' span shall be capable of sustaining a working load of 145 pounds per lineal foot with a load deflection of 1.0" when tested in accordance with NEMA VE1-3.01. Approved Manufactures:
  - 1. B-Line
  - 2. Chalfant
  - 3. Cope
  - 4. Globetray
  - 5. Husky
  - 6. Mono-Systems
  - 7. Square D
  - 8. Wiremold.
- B. Center spline cable tray shall be aluminum, of the width shown, with top mounted rungs, 3" load depth, 13/16" minimum rung width, and 9" maximum rung spacing. The tray with a 10' span shall be capable of sustaining a working load of 145 pounds per lineal foot with a load deflection of 1.0" when tested in accordance with NEMA VE1-3.01.
- C. Tray fittings including horizontal and vertical bends, tees, crosses, reducers, splice plates and expansion joints shall be from the same manufacturer and of the same product line as the tray. Bends, tees, crosses and reducers shall have a 13/16" minimum rung width, a 9" maximum rung spacing, and a 12" minimum bend radius.
- D. Tray fasteners shall be galvanized or zinc plated steel.

## 2.03 SURFACE RACEWAYS

- A. Where surface raceways are called for on the drawings, or when conduits in finished areas cannot be concealed in walls or above ceilings, surface raceways shall be used. Boxes and fittings shall match and be from the same manufacturer as the surface raceway.
- B. Surface raceways shall consist of a base and cover, sized for the number of conductors contained within, complete with all connectors, fittings, bushings, boxes, covers and mounting hardware.
- C. Raceways shall be 600 volt rated, and be in compliance with the applicable paragraphs of NEC Article 352.
- D. They shall be non-flammable, and UL labeled, under UL 5, or UL 5A (as applicable).
- E. The completed raceway system shall be vandal resistant.
- F. Shall accept receptacles, cover plates, telephone/data outlets and other standard wiring devices as specified elsewhere in these specifications.

- G. The coverplates used for wiring devices and telecommunication outlets shall be of the 'overlapping' type, and shall therefore cover the 'cut-end' of the raceway cover.
- H. The raceways shall have "scuff" resistant finish, and the raceways shall be paintable.
- I. All components of the raceway system exposed to view shall be of the same color and shade.
- J. Barriers shall be provided when necessary to separate conductors of different voltages, or services.
- K. Surface raceways shall be steel or plastic as noted below, and as noted on the drawings:
- L. Type Standards Manufacturers
  - 1. Metallic
    - a. Metallic raceways shall be of .040" thick (minimum) zinc plated or galvanized steel.
    - b. The acceptable levels of quality are, generically,
      - 1) Like "Wiremold V500 and V700" for smaller single channel raceway applications,
      - 2) Like "Wiremold V3000" for larger single channel raceway applications, and
      - 3) Like "Wiremold V4000" for larger multi-channel raceway applications.
    - c. Manufacturers include Wiremold, Hubbell, Thomas and Betts, or Mono-System.
  - 2. Plastic
    - a. Plastic raceways shall be of a material meeting all of the requirements of UL 5A, (including flammability, resistively structural strength, etc.).
    - b. The acceptable levels of quality are, generically,
      - 1) Panduit LD series, or Carlon Series 30 for smaller single channel raceway applications;
      - 2) Panduit Type T-70, or Carlon "Premiere", for larger single channel raceways, and smaller multi-channel raceways; and
      - 3) Panduit Twin 70 or Carlon "Prestige", for larger multi-channel raceway applications.
    - c. Manufacturers include Panduit, Carlon, Hubbell, Mono Systems, and Wiremold.
- M. Use vertical surface raceways from junction boxes above the ceiling, to the horizontal portion of the surface raceway. Locate vertical section as close to room corners (or 'vertical breaks' in mid wall) as is possible. Use of exposed vertical conduits is not acceptable.

#### 2.04 BOXES

- A. Boxes for fixtures, outlets, switches, equipment connections and wire pulling shall be
  - 1. Cast or formed from carbon steel sheets of commercial grade steel not less than 14-gauge,
  - 2. One-piece construction, zinc, or cadmium plated,
  - 3. Tapped for mounting plates and covers as required.
- B. Pull and junction boxes shall be
  - 1. Fabricated from galvanized or painted code gauge cold rolled carbon steel sheets.
  - 2. Welded construction with flat removable covers fastened to the box with machine screws.

3. Seams and joints shall be closed and reinforced with flanges formed of the same material from which the box is constructed or by continuous welding which will provide equivalent strength to flange construction.
  4. Preferably not provided with 'knockouts'.
- C. Box covers shall be fastened in place by machine screws or hinges and latches. Self-tapping or sheet metal fasteners are not acceptable.

## 2.05 SUPPORTS

- A. Hangers and brackets shall be made of steel pipe, channel iron, angle iron or prefabricated steel channel. Prefabricated steel channel shall be by B-Line, Hilti, Powerstrut or Unistrut.
- B. Anchors shall be lead shield anchors or plastic expansion anchors for small loads, and expansion or epoxy anchors for large loads. Powder-driven anchors shall not be used.

## 2.06 LABELS AND DIRECTORIES

- A. Equipment nameplates shall be engraved .125 inch (1/8") thick 'Lanaloid' (Lanacoid) plastic. White, with black letters. The engraved letters shall be at least one quarter inch (1/4") high.
- B. Receptacles and lighting switch covers shall be labeled using clear adhesive backed nylon or Mylar tape with black text permanently laminated to the tape.
- C. Panel directories shall be typed on supplied card stock with panel, or card stock similar in thickness and material as those supplied with the panels. Install supplied clear plastic cover, or one of like material.

## PART 3 - EXECUTION

### 3.01 GENERAL

- A. All work shall conform to all applicable Codes and Construction Standards.
- B. All installations shall be warranted for a period of one (1) year against defects in material and workmanship.
- C. The Owner reserves the right to relocate any device fifteen (15) feet prior to installation at no additional cost.
- D. Material Storage
  1. All materials shall be new and in original factory packaging.
  2. All material shall be kept dry and clean.
  3. The Owner reserves the right to reject any material not properly stored.
- E. Contractor shall swab clean the interior of all raceway prior to pulling wire.
- F. Device plate screw slots shall be oriented vertically.

### 3.02 RACEWAYS

- A. Size conduits in accordance with the NEC, but not less than the sizes shown on the drawings. Minimum power, fire alarm and control conduit size shall be 3/4". Minimum telecommunications conduit size shall be 1".
- B. Install concealed and exposed conduits and cable trays parallel to or at right angles to building lines. Conduits shall not be embedded in concrete slabs except where specifically

shown. Install surface raceways as close to room corners or trim features as possible to make the surface raceways less obvious.

- C. Make directional changes in primary power distribution conduits above ground with sweeps and long radius elbows, and underground with 20' minimum radius bends.
- D. Conceal conduits wherever possible and practical. When conduits cannot be concealed in finished areas, use surface raceways with matching boxes from the same manufacturer as the raceways.
- E. Metal conduits, fittings, enclosures and raceways shall be mechanically joined together in a firm assembly to form a continuous electrical conductor providing effective electrical grounding continuity.
- F. Provide expansion fittings at the intervals specified in the manufacturer's instructions.
- G. Conduits entering panels located outdoors, in parking structures, in steam tunnels and on cooling towers shall enter from the sides, back, or bottom. Conduits shall not enter from the top.
- H. Separate raceways from uninsulated steam pipes, hot water pipes, and other hot surfaces by a minimum of 4" horizontally or 12" vertically. Separate raceways from ventilation ducts and insulated pipes so that they do not come into contact with each other.
- I. Low voltage signal circuits shall be separated or shielded from power circuits to prevent the induction of noise into the signal circuits.
- J. EMT entering sheet metal enclosures and outlet boxes shall be secured in place by a connector with a locknut. Rigid conduit shall be secured with locknut inside and outside and a bushing. Sufficient thread on the connector or conduit shall extend into the enclosure so that the bushing will butt tight into the connector or conduit. Bushings shall not be used as jamb nuts or in lieu of locknuts.
- K. Flexible metallic conduit to motors and similar equipment shall not exceed 3'-0" in length, and shall have adequate slack to absorb the maximum vibration. Flexible conduit connections to lighting fixtures shall not exceed 6'-0" in length.

### 3.03 MOUNTING HEIGHTS

- A. Except where shown otherwise, install equipment and devices at the following heights:
  - 1. Receptacles (Wall): 18" A.F.F. to center
  - 2. Receptacles (Above Counter): 48" A.F.F. to center or 4" minimum above countertop or backsplash.
  - 3. Receptacles (Unfinished Area): 48" A.F.F. to center
  - 4. Surface Raceway Receptacle Strips: 42" A.F.F. to bottom
  - 5. Light Switches: 48" A.F.F. to center
  - 6. Telephone Outlets (Wall Phone): 48" A.F.F. to center
  - 7. Telephone/Data Outlets: 18" A.F.F. to center
  - 8. Clock Outlets: 88" A.F.F. to center
  - 9. Fire Alarm Pull Stations: 45" A.F.F. to center
  - 10. Fire Alarm Horn/Strobes: 80" A.F.F. to bottom or 1' below finished ceiling which ever is lower.
  - 11. Card Readers: 48" A.F.F. to card slot
  - 12. Security System Controls: 48" A.F.F. to center

13. Thermostats/HVAC Controls: 48" A.F.F. to center
14. Panelboards: 72" A.F.F. to top
15. Safety Switches/Motor Starters: 72" A.F.F. to top (except top of handle shall not exceed 78" A.F.F.)
16. Motor Control Pushbuttons: 60" A.F.F. to center
17. Verify with the Owner for heights not otherwise listed.

#### 3.04 SUPPORTS

- A. Provide 4" thick concrete housekeeping pads for floor-mounted equipment.
- B. Support all electrical items independently of supports provided by the other trades.
- C. Support conduits and boxes using steel conduit straps or 1/4-inch minimum diameter threaded rod hangers. Suspended ceiling hangers or hanger wire shall not be used (except to support flexible metallic conduit and manufactured wiring systems).
- D. Support cable trays with support brackets or 3/8" diameter minimum threaded rod hangers at intervals not exceeding 8'-0" for straight runs. Additional supports shall be provided at tray fittings.
- E. Hangers shall be of sufficient strength that their deflection at mid span does not exceed 1/240 of the hanger span length after the cables are installed.
- F. Route flexible metallic conduit, manufactured wiring systems and Type MC cable parallel to or perpendicular to building lines, and in a neat and workmanlike manner. Coil the excess manufactured wiring systems and Type MC cable, and support independently of the ceiling grid system at intervals not exceeding 3 feet.

#### 3.05 PENETRATIONS, SLEEVES AND FIRE SEALS

- A. Cut floor and wall penetrations neatly and to the minimum size required for installation of the equipment and raceways.
- B. Provide galvanized steel pipe sleeves for all conduits penetrating floors, exterior walls and roofs.
  1. Extend floor sleeves above the floor a minimum of 2 inches.
  2. Embed sleeves in new concrete or step-core concrete and grout sleeves into existing concrete with epoxy grout.
  3. Seal floor sleeves using fire-sealing systems approved by a Nationally Recognized Testing Laboratory.
  4. Seal exterior wall and roof penetrations water tight.
- C. Patch both sides of wall penetrations cut for electrical equipment and raceways to seal against the passage of air, sound and fire.
  1. Seal cable tray penetrations in fire rated walls using fire sealant bags approved by a Nationally Recognized Testing Laboratory.
  2. Seal conduit penetrations in fire rated walls using firesealing caulk approved by a Nationally Recognized Testing Laboratory.
  3. Seal conduit penetrations in non-rated walls using masonry materials that match the wall construction.
  4. Fire seal between recessed outlet boxes located on opposite sides of a fire rated wall if the box openings are over 16 square inches and the boxes are less than 24 inches apart.

#### 3.06 EXPANSION FITTINGS

- A. Provide expansion fittings at all building expansion joints.
- B. Provide expansion fittings, in accordance with manufacture recommendations, in all areas subject to swings in temperature of more than 15 degrees C.
- C. Install expansion fittings in all locations where expected expansion difference is ¼", or more, between boxes

### 3.07 IDENTIFICATION

- A. Provide nameplates and labels in accordance with Article 2.6.
  - 1. Lanaloid labels shall be mechanically secured in place with sheet metal screws and/or bolts and nuts
  - 2. Labels shall be neatly centered. Place labels in like positions on similar equipment.
- B. Color code wiring as noted in Section 260519 3.01 B
- C. Color code junction boxes and box covers of
  - 1. Emergency power circuits with red paint
  - 2. Fire alarm circuits with red paint.
  - 3. Temperature control circuits with blue paint.
  - 4. Phone and Data circuits with orange paint.

END OF SECTION 260500

## SECTION 260502 – SELECTIVE ELECTRICAL DEMOLITION

### PART 1 – GENERAL

#### 1.01 SCOPE OF WORK

- A. Demolition of electrical items and associated materials as indicated herein or as indicated on the drawings.

#### 1.02 SECTION INCLUDES

- A. Removal of designated equipment and devices.
- B. Removal of designated construction.
- C. Disposal or storage of removed materials.
- D. Identification of utilities.
- E. Refer to items as indicated.

#### 1.03 SUBMITTALS FOR CLOSEOUT

- A. Project Record Documents: Accurately record actual locations of terminated utilities and subsurface obstructions.

#### 1.04 REGULATORY REQUIREMENTS

- A. Conform to applicable code for demolition work, safety of structure, dust control, products requiring electrical disconnection and re-connection.
- B. Obtain required permits from authorities.
- C. Do not close or obstruct egress width to any building or site exit.
- D. Do not disable or disrupt building fire or life safety systems without 3 days prior written notice to Owner.
- E. Conform to procedures applicable when hazardous or contaminated materials are discovered.

#### 1.05 SCHEDULING

- A. Perform work between the hours of 7 a.m. and 7 p.m.

#### 1.06 PROJECT CONDITIONS

- A. Conduct demolition to minimize interference with adjacent and occupied areas.
- B. Maintain protected egress and access to the Work.

### PART 2 – NOT USED

### PART 3 – EXECUTION

#### 3.01 PREPARATION

- A. Protect existing materials which are not to be demolished.
- B. Notify affected utility companies before starting work and comply with their requirements.
- C. Utilize OSHA lockout/tag-out procedures for disconnecting means.
- D. Label all wiring to remain (phase and device fed) to assure proper re-connection.
- E. Mark location and termination of utilities.

#### 3.02 DEMOLITION

- A. Disconnect, remove, cap, identify designated utilities to remain and demolish in an orderly and careful manner.
- B. Remove demolished materials from site except where specifically noted otherwise.
- C. Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.

### 3.03 PROTECTION OF SALVAGED ITEMS

- A. Remove, store and protect the materials and equipment scheduled to be re-used.
- B. Protect wiring to be re-used by means of a Junction Box
  - 1. Junction Box shall be of sufficient size to permit reconnection of existing wiring to new wiring per NEC Requirements.
  - 2. In outdoor locations the junction box shall be NEMA 3R or a custom junction box with welded seams and gasketed cover.

END OF SECTION 260502

## SECTION 260519 – LOW VOLTAGE WIRE AND CABLE

### PART 1- GENERAL

#### 1.01 DESCRIPTION OF WORK

- A. Extent of electrical wire and cable work is indicated by the Project drawings.
- B. Types of wire, cable and connectors in this section include the following
  - 1. 600 volt insulated copper conductors
  - 2. Twist on insulated metal spring connectors
  - 3. Compression connectors
  - 4. Split Bolt connectors

#### 1.02 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of electrical wire and cable of types sizes and ratings required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installers: Firm with at least five (5) years of successful installation experience with projects utilizing electrical wiring and cabling work similar to those required for this Project.
- C. NEC Compliance: Comply with NEC requirements as applicable to construction, installation and color coding of electrical wires and cable.
- D. U.L. Compliance: Comply with applicable requirements of UL Standard 83, "Thermoplastic-Insulated Wires and Cables", and UL Standard 486A, "Wire Connectors and Soldering Lugs For Use With Copper Conductors".
- E. UL Labels: Provide wire, cable and connectors which are UL listed and labeled.

#### 1.03 DELIVERY, STORAGE AND HANDLING

- A. Deliver wire and cable properly packaged in factory-fabricated type containers or wound on NEMA Specified type non-returnable wire and cable reels.
- B. Store wire and cable in a clean dry space. Protect products from weather, damaging fumes, construction debris and traffic.
- C. Handle wire and cable carefully to avoid abrading, puncturing, or tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wire and cable is maintained.

### PART 2 PRODUCTS

#### 2.01 ACCEPTABLE MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufactures offering products which may be used on this Project include, but not limited to, the following:
  - 1. Low Voltage Wire:
    - a. American Insulated Wire and Cable

- b. Southwire Company
  - c. Others as Approved
- 2. Electronic Cable
  - a. Belden
  - b. Alpha
  - c. Anixter
- 3. Twist on insulated metal spring connectors
  - a. Ideal
  - b. Thomas and Betts Corp
  - c. 3M Company
- 4. Compression
  - a. Square D / Anderson
  - b. Thomas and Betts

## 2.02 DESCRIPTION THHN / THWN

### A. Conductor:

- 1. Bare, soft annealed copper per ASTM B-3.
- 2. Sizes 14 - 10 AWG: Solid, bunched, unilay concentric combination unilay or compressed stranded (class C) alternate ASTM B-787, ASTM B-3 or ASTM B-8 and UL-83.
- 3. Sizes 8 - 2 AWG: Concentric, compressed stranded (class C) alternate ASTM B-787, ASTM B-8, UL-83 and UL-1063.
- 4. Sizes 1 AWG - 750 KCMIL: Concentric, compressed stranded (class B) ASTM B-8, UL-83 and UL-1063.

### B. Insulation:

- 1. High dielectric polyvinyl chloride (PVC) per UL-83 and UL-1063.
- 2. Overall Jacket: Nylon per UL-83 and UL-1063.

### C. Cable Identification:

- 1. Ink print on jacket for Sizes 14 - 10 AWG (solid conductors): "(size) AWG Type THHN or THWN GAS AND OIL RES II 600V(UL) or AWM VW-1---(Company Name).---C-UL Type T90 NYLON or TWN 75"
- 2. Ink print on jacket for Sizes 14 AWG - 750 KCMIL (stranded): "(size) AWG (or KCMIL) Type MTW or THHN or THWN or GAS AND OIL RES II 600V (UL) or AWM---(Company Name).---C-UL Type T90 NYLON or TWN 75."
- 3. Also "VW-1" and "FT1" on sizes 14 through 6 AWG and "for CT USE SUN RES" on sizes 1/0 AWG and larger in black.

### D. Cables conform to the following standards:

- 1. UL-83 for THHN-THWN, UL-1063 for MTW (stranded conductors only)
- 2. Federal Specification J-C-30B, NEMA WC-5, UL-758 for AWM Styles 1316 through 1321, 1408 through 1414, 1452 and 1453.

### 2.03 ELECTRONIC CABLE - COMMUNICATION AND SIGNAL

- A. Shall conform to the recommendations of the manufacturers of the communication and signal systems; however, not less than what is shown.
- B. Wiring shown is for typical systems. Provide wiring as required for the systems being furnished.
- C. Multi-conductor cables shall have the conductors color coded.

### 2.04 CABLES AND CONNECTORS

- A. General: Provide electrical cables and connectors of Manufacturer's standard materials, as indicated by published product information.
- B. Provide copper conductors with conductivity of not less than 98% at 68° F (20° C).
- C. Electronic cable shall be Plenum rated and as recommended by the Equipment Supplier
- D. Connectors shall be for copper to copper connections
- E. Insulation: All connectors shall be fully insulated to match insulation type and rating of conductors being spliced.

## PART 3 – EXECUTION

### 3.01 INSTALLATION OF WIRES AND CABLES

- A. General: Install electrical cables, wires and wiring connectors as indicated, in compliance with applicable requirements of NEC, NEMA, UL and NECA's "Standard of Installations", and in accordance with recognized industry practices.
- B. Feeder phase identification from left to right or front to back facing front of equipment shall be one of the following:

Phase A	Phase B	Phase C	Neutral	System
X	Y	Z	N	Any voltage
BLACK	RED	BLUE	WHITE	120/208 volt feeders
BROWN	ORANGE	YELLOW	GRAY	277/480 volt feeders

- C. Install all wiring in conduit except as indicated on the drawings or directed by Owner.
- D. Pull conductors together where more than one is being installed in a raceway.
- E. Use pulling compound or lubricant where necessary. Compound must not deteriorate conductor or insulation. Use of soap is not permitted as a pulling lubricant.
- F. Pulling means must not damage cable or raceway.

### 3.02 COMPRESSION CONNECTORS

- A. Use only compression indenter tools designed for the type of connector used.
- B. For multiple indentations start at center and indent outward.

### 3.03 FIELD QUALITY CONTROL

- A. Prior to energizing, test all cables and wires with "Megger" to determine insulation resistance levels to ensure insulation integrity.
- B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.

END OF SECTION 260519

## SECTION 260526 – GROUNDING AND BONDING

### PART 1 - GENERAL

#### 1.01 SUMMARY

- A. Provide grounding for all systems and equipment.

#### 1.02 GROUNDING SYSTEM REQUIREMENTS

- A. Each ground rod shall have a maximum resistance to ground of 10 ohms before connection to the other ground rods. If reading is above 10-ohms, drive one extension. Further testing of that individual rod is not needed.
- B. The total grounding system with all connections completed shall have a maximum resistance to ground of 2 ohms for primary services or 5 ohms for secondary services.

#### 1.03 CONNECTION REQUIREMENTS

- A. Provide exothermic weld type, or Burndy Hyground, ground connections for concealed, underground, and concrete encased ground connections, for ground connections to structural steel, connections between sections of the main ground bus and all connections to the substation room ground bus bars.
- B. Exposed ground connections (except connections to structural steel and substation room ground bus bars) may be made with copper or bronze compression ground fittings or bolted compression ring lugs.
- C. Provide exothermic weld type, or Burndy Hyground ground connections for splices and taps of grounding conductors No. 8 AWG and larger. Exposed splices and taps shall be taped.

### PART 2 - PRODUCTS

#### 2.01 GROUND RODS

- A. Unless shown otherwise, ground rods shall be 3/4" diameter by 10' long, copper clad steel. Ground rods shall be capable of being extended when additional length is required.

#### 2.02 GROUNDING CONDUCTORS

- A. Grounding conductors for direct burial underground, for encasement in concrete, and for grounding of unit substations shall be No. 4/0 AWG minimum, bare, stranded copper.
- B. Grounding conductors for general use shall be stranded, copper conductor, sized in accordance with the NEC unless shown otherwise on the drawings, and insulated with green NEC Type THHN insulation rated 90 degrees C, 600 volts.

#### 2.03 GROUND CONNECTIONS

- A. Ground connections shall be Burndy Hyground, Cadweld, Thermo-weld or Thomas & Betts Blackburn only.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION REQUIREMENTS

- A. Ground duct banks and manholes in accordance with Specification Section 260513
- B. Provide bare copper grounding conductors from duct banks, manholes, unit substations, primary switches, transformers, switchgear, panelboards, motor control centers and control panels to the building grounding system. Equipment rated above 480 volts or 600 amps shall be grounded by a minimum of two independent grounding conductors.
- C. Bond transformer, UPS system, central battery/inverter system, emergency generator, and separately derived electrical system neutrals to the building grounding system.

- D. Ground motors rated 460 volts and below by motor feeder equipment grounding conductors. Stranded copper grounding conductors connected to building steel shall also bond motors rated over 460 volts.
- E. Provide green insulated equipment grounding conductors in all service, feeder, and branch circuits for connection of load devices to the power source ground. Raceways shall not be used as equipment grounding conductors.
- F. Equipment grounding conductors shall not be daisy-chained.
- G. Bond equipment-grounding conductors in boxes and enclosures where the grounding conductors are terminated or spliced.
- H. Bond conduits, cable trays, wireways, surface raceways, boxes, and enclosures together, and to the building grounding system. Provide bonding bushings and bonding jumpers to bond conduits where they enter a box or enclosure.
- I. Ground the lightning protection system with separate ground rods. The building grounding system ground rods shall not be used. After completion of both systems, the lightning protection system shall be bonded to the building grounding system.
- J. Protect separately routed grounding conductors subject to damage or physical abuse by Schedule 40 PVC nonmetallic conduits. Grounding conductors shall not be routed in metallic conduits except when routed with phase conductors.

END OF SECTION 260526

## SECTION 260533 – RACEWAYS AND BOXES

### PART 1 – GENERAL

#### 1.01 SUMMARY

- A. This Section specifies raceways and boxes for building and structure electrical systems under 600 volts.
- B. Provide all labor, materials, and equipment as necessary to complete all work as indicated on the drawings, and as specified herein.
- C. Related Sections:
  - 1. Division 1 - General Requirements
  - 2. Applicable sections of Division 26 - Electrical

### PART 2 – PRODUCTS

#### 2.01 GENERAL INFORMATION

- A. All boxes, brackets, bolts, clamps, etc., shall be galvanized or electro-galvanized.
- B. All hardware used outdoors shall be hot dipped galvanized.

#### 2.02 CONDUIT

- A. Rigid galvanized conduit shall be installed in poured concrete slabs, walls and partitions. Rigid or I.M.C. shall be installed in damp locations and inaccessible places.
- B. All rigid conduit, I.M.C. and E.M.T. shall be hot dipped galvanized or electro-galvanized.
- C. E.M.T. may only be installed exposed, above suspended ceilings, or in partitions.
- D. Flexible steel conduit may be used for short runs to individual pieces of equipment.
- E. Flexible sheathed metallic conduit shall be used for runs less than 6' in length to individual pieces of equipment in mechanical rooms, penthouses, etc.
- F. MC Cable is permitted in existing walls where installation of EMT is not possible to devices
- G. No E.M.T. or aluminum conduit shall be used in concrete, direct burial or in corrosive locations.
- H. Aluminum conduit may only be used in sizes 1-1/2 inch and larger. No aluminum conduit will be permitted in concrete. When aluminum conduit is used, all bends shall be galvanized steel.
- I. Size and type of conduit shall comply with the National Electric Code. Where conduits are indicated on the drawing to be larger than required by Code, the larger conduit shall be used.
- J. Minimum conduit size shall be 3/4 inch in all runs.

#### 2.03 PULL AND JUNCTION BOXES

- G. All pull boxes shall be galvanized sheet steel, sized as required, with thickness not less than no. 14 gauge.

#### 2.04 OUTLET BOXES

- A. All outlets, except as otherwise specified, shall consist of approved galvanized steel boxes of pattern adapted to the special requirements of each outlet, securely fastened in place in an approved manner.

### PART 3 – EXECUTION

#### 3.01 CONDUIT

- A. Conduit shall be concealed in all new walls and run above suspended ceilings.
- B. Use Wiremold type metal raceway where necessary to run exposed on existing walls and/or

ceilings in finished areas as shown on the drawings.

- C. All conduit shall be fastened or suspended from structural members, slabs, or walls only. It shall not be run on or fastened to tee bars of suspended lay-in ceilings.
- D. All conduit shall be supported by approved hangers at spaced per NEC.
- E. All exposed conduit shall be run parallel to the structural members of the building in a neat manner, securely fastened in place.
- F. When metal conduit extends below the bottom of a slab on the ground, the slab shall be thickened in the area of the conduit so as to encase the conduit in concrete by at least 2 inches on all sides. The responsibility for and expense of this work shall be borne by the Contractor.

### 3.02 OUTLET BOXES

- A. Recessed outlet boxes for single gang or 2-gang installations shall be 4" square with appropriate device ring or plaster ring for the required number of devices.
  - 1. All device rings and plaster rings shall be installed vertically unless instructed otherwise by the A/E or Owner.
  - 2. All plaster rings shall not extend past flush with wall surface or be recessed more than 1/4" from wall surface.
- 3. For installations of more than two devices use the appropriate wall box for the number of devices required. If approved by the Owner the use of gangable wall boxes is allowed.
- 4. For surface installations in Mechanical Area or similar locations 4" square boxes shall be used with 1/4" raised cover.

### 3.03 PULL AND JUNCTION BOXES

- A. Pull boxes shall not be installed in inaccessible locations.

END OF SECTION 260533

## SECTION 260572 – POWER SYSTEM ACCEPTANCE TESTING

### PART 1 – GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this Section.

#### 1.02 SUMMARY

- A. Procure the services of an acceptable testing engineering company to provide necessary test equipment and field test all power distribution work, including the following equipment and system components, and record and report the results.
  - 1. Ground electrode systems and equipment bonding.
  - 2. Testing of cables, 600V class and 15KV class.
  - 3. Megger testing of switchgear, transformers, switchboards, and panels.
  - 4. Phase sequencing of cables, transformers, switchgear, switchboards and panels.
  - 5. Test power circuit breaker operation.
  - 6. Determine power circuit breaker trip set-points and time delays to provide short circuit protection and coordination. Make breaker adjustments accordingly.
- B. Suggested testing engineering company
  - Eaton Engineering Services
  - Louisville KY
  - Rick King (502)-961-5501
- C. Replace all work and equipment found to be defective under tests and repeat specified tests on replaced work.
- D. Testing Objectives:
  - 1. Determine that the cables and equipment involved may be energized for final operational tests.
  - 2. Assure that the methods and materials used in manufacturing and installation have provided a power system that is in a safe and operable condition consistent with accepted industry standards.
- E. Qualifications:
  - 1. Electrical Contractor or Independent Testing Engineer: engaged in the business of electrical acceptance testing, similar to the inspections and tests specified; have a minimum of three (3) years experience.
    - a. Test Personnel: have a minimum of three (3) years supervised field experience.
    - b. Certification: testing engineer shall be certified by the National Electrical Testing Association or be a registered professional engineer.
    - c. Provide equipment list and dates of calibration.
- F. Test Report:
  - 1. Test Report: a certified test report in a bound format shall be prepared and submitted for review incorporating the following:
    - a. Summary of the project.
    - b. Description of inspections performed.

- c. Description of cables and installation.
    - d. Description of tests performed.
    - e. List of test equipment used and calibration dates.
    - f. Test results.
    - g. Conclusions and recommendations.
  2. Where modifications, or repairs are made in order to meet system specifications, the test results and report shall indicate the final "as installed" condition.
  3. Test Forms: acceptable equivalent to NETA copyrighted test report forms; include but not be limited to the following data;
    - a. Nameplate catalog number, serial number and rating.
    - b. Desired performance or performance range.
    - c. Measured performance.
    - d. Test equipment used.
    - e. Test personnel and date.
    - f. Any discrepancies or repairs made.
    - g. Environmental and physical conditions.
- F. Scheduling:
1. Due to installation scheduling of specific items or for other valid reasons, testing may be subdivided into several small packages. In that case, one certified copy of a test report shall be submitted no later than thirty (30) days after completion of each test package and an inclusive test report containing the package reports shall be submitted in the quantity and within the time specified for the complete report.

## PART 2 – PRODUCTS (NOT USED)

## PART 3 - EXECUTION

### 3.01 TESTING METHODS

#### A. Test Procedure:

1. Utilize project electrical documents to assist in ascertaining the extent of the project testing.
2. Provide necessary test equipment and be responsible for setting-up test equipment, wire checks of factory wiring, and all other preliminary work in preparation for electrical acceptance tests.
3. Test in cooperation with other affected contractors. Schedule of tests shall be coordinated with work of other contractors and Owner's operations, and approved by Owner prior to testing.
4. Advise manufacturer's representative of tests to be performed on their products, prior to testing, to permit them to witness the test should they so desire.
5. Test in the presence of representatives of the Owner and the Engineer at the option of respective representatives. Contractor shall advise time of test 48 hours in advance.
6. Tests shall be non-destructive and shall not exceed the manufacturer's recommended limit for the products being tested. Method of testing cable shall have approval of cable manufacturer and shall conform to all applicable standards of IPCEA.

7. Where required for the validity of tests or safety of equipment and personnel, isolate equipment to be tested from the system.
8. Report immediately to Engineer all systems, materials or workmanship which is defective or not in compliance with the specifications.

B. Visual Inspection:

1. Prior to testing, the installation shall be visually inspected to determine that there is no physical damage, that there are no loose or missing parts, and that products supplied are in agreement with the contract documents and properly installed and connected.

C. Environmental Conditions:

1. Temperature:

- a. Both actual ambient temperature test readings and calculated test values, corrected to 20 degrees centigrade (20 degrees C, shall be reported.
- b. Do not test when the insulation temperature is below 0 degrees C.

2. Humidity:

- a. Do not test when the relative humidity is above 70 percent (70%). Deviations to this requirement will be allowed if it can be demonstrated that the higher humidity will not affect the test or that the higher humidity can be accounted for adequately in interpreting the test results.

D. Insulation Resistance (Megger) Test:

1. Subject cables to an insulation resistance test prior to any other tests or energizing.
2. Voltage Source (Megger): capable of providing a constant D.C. voltage for the time intervals as specified below. Hand cranked meggers shall not be used for D.C. voltages greater than 500 volts.
3. Magnitude of Applied D.C. Voltage: depend upon voltage of system to which equipment is connected, as follows:

<u>System Voltage</u>	<u>Test Voltage</u>
150 and under	500
151 to 600	1000
601 and above	2500

4. 2500 Volt Insulation Resistance Tests: Held a minimum of five (5) minutes, and until three equal consecutive readings one minute apart are obtained. Readings shall be taken and recorded every 30 seconds during the first two minutes, and every minute thereafter.
5. 1000 Volt and 500 Volt Insulation Resistance Tests: held for a minimum of one minute and until the reading reaches a constant value for 15 seconds unless specified otherwise.
6. Apply tests from phase to ground with the other phases grounded. Each phase shall be tested in a similar manner.
7. Phase Matching and Phase Identification: checked immediately prior to energizing of equipment.

E. High Potential Tests:

1. Cables and Bus over 600 Volts: Given a high potential D.C. test after splices and stress cones are completed.
2. New Cables: Tested after cables are connected to terminals, to simultaneously test terminations.
3. Proper Safety Precautions: Taken at each point where cable has exposed connections, to prevent personnel from coming in contact with the cable.

4. Insulation Resistance Test: Performed on each cable prior to a high potential test.
5. Test Voltage: Test at 55 KV for new 15 KV class cables; verify with cable and switchgear manufacturer's recommendations; IPCEA standards may be used if manufacturer's recommendations are not available.
6. D.C. Test Potential: Applied in at least eight (8) equal increments until maximum test voltage is reached. Initial application of voltage shall not be greater than rated voltage of cable.
7. D.C. Leakage Current: Recorded at each step after a constant stabilization time consistent with system charging current delay.
8. Graphic Plot: Made of leakage current versus applied potential at each increment.
9. After reaching test voltage, potential shall be maintained for ten minutes. Readings of leakage current shall be recorded every minute.
  - a. After ten-minute test, record the decay voltage after one minute, and decay time to 1000 volts.
10. Graphic Plot: Made of leakage current versus time.
11. Conductor Test Potential: Reduced to zero at completion of each conductor test and grounds shall be applied for a minimum of ten (10) minutes.
12. Switches or Other Equipment Connected to a Cable Being Tested: Shall not be subjected to a test voltage in excess of their test rating. In case of conflict, disconnect equipment.
13. Each Conductor: Individually tested with other conductors grounded. Shields shall be grounded.

### 3.02 TESTING CABLES OVER 600 VOLTS

- A. Insulation Resistance Test: performed prior to cable connection.
- B. High Potential Test: performed as specified.
- C. Shield Continuity Test: performed on shielding of shielded cables by measuring D.C. resistance from end to end. Shield shall be checked for ground connection.

### 3.03 TESTING GROUNDING SYSTEMS

- A. Mechanical Inspection: Grounding system shall be inspected to determine that connections are secure and do not constitute open or high resistance joints. Bolted connections shall be tested with a torque wrench, minimum torque for bolts 3/8-inch diameter and larger shall be 50 ft.-lbs.
- B. Ground resistance: Ground electrode system shall be tested to determine effective resistance to ground.
- C. Equipment ground continuity: Test continuity and bonding to ground of power feeder conduits, equipment enclosures, metallic piping, and equipment ground conductors.

### 3.04 TEST REPORT

- A. Prepare test report and recommendations, and submit to Engineer for review and comment.
- B. Include final version of test report as part of Operation and Maintenance Manual. Final version shall include any information, revisions, or results of additional tests requested by Engineer during initial review.

END OF SECTION 260572

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## SECTION 260573 – SHORT CIRCUIT AND PROTECTIVE DEVICE COORDINATION STUDY

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. Provide a protective device coordination study for the new electrical distribution system provided by this project and those portions of the existing electrical power distribution system affected by this project. It is not intended that the entire building be included in the study.
- B. The study shall include a short-circuit study and equipment-interrupting or withstand evaluation on all portions of the electrical distribution system from the normal and emergency sources of power through the low-voltage distribution systems to the branch circuit panelboard level. All modes of operation shall be thoroughly covered in the study.

### PART 2 – PRODUCTS (NOT USED)

### PART 3 – EXCUTION

#### 3.01 Short-Circuit Study

- A. The study shall comply with applicable ANSI and IEEE standards.
- B. Input data shall include the campus utility's single and three-phase short-circuit contribution with the X/R ratio, the resistance and reactance components of each branch impedance, generator and motor contributions, and all other applicable circuit parameters.
- C. Short-circuit momentary and interrupting duties shall be calculated on the basis of maximum available fault current at each bus, switchboard, panelboard, motor control center or other significant location throughout the system.

#### 3.02 Equipment Evaluation Study

- A. An evaluation study shall be submitted prior to final approval of equipment submittals. Adequacy of circuit breakers, controllers, surge arresters, busways, fuses and switches shall be determined by tabulating and comparing the short-circuit ratings of these devices with the maximum duties.

#### 3.03 Protective Device Coordination Study

- A. The selection of power fuse ratings, protective-relay characteristics and settings, low-voltage circuit breaker trip characteristics and settings and characteristics of associated voltage and current transformers shall be determined.
- B. The study shall include all equipment included in this project from the secondary unit substation distribution circuit breakers to each new panelboard and new motor control center. Phase and ground overcurrent protection shall be included as well as settings for all other adjustable protective devices.
- C. Coordination shall be in compliance with the NEC and IEEE Standard 399.
- D. Protective devices and settings shall be provided in tabulated form. Circuit Identification, IEEE device number, CT ratios, manufacturer, type, range of adjustment and setting shall be listed. Recommended fuse selection shall be provided for every fuse in the system. Recommended protective relay trip settings and time delay settings shall be provided for each circuit breaker in the system.
- E. Discrepancies or other problems shall be identified.
- F. Coordination curves shall be provided for each circuit breaker and each major component in the system. Indicate generator, equipment, and motor damage curves and protection curves on the same base.

#### 3.04 The study shall be summarized in a final report including:

SHORT CIRCUIT AND PROTECTIVE DEVICE COORDINATION

260573 - 1

- A. Summary of findings.
  - B. Description, purpose and scope including a one-line diagram.
  - C. Fault-current tabulations including a definition of terms.
  - D. Evaluation of equipment for fault duty.
  - E. Coordination curves and tabulations of relay and circuit breaker trip settings, fuse selection and commentary.
  - F. A copy of the final reviewed and approved study shall be included with each O & M manual.
- 3.05 Approved Power System Study Providers
- A. Power System Study provider approved/suggested for this project:
    - 1. Eaton Engineering Services  
Louisville KY  
Rick King (502)-961-5501
    - 2. JW Sims and Associates  
Indianapolis, IN  
(317)-209-4035
  - B. All others must submit for approval prior to Bidding

END OF SECTION 260573

## SECTION 260923 – LIGHTING CONTROLS

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install a lighting control as specified and as shown on the contract drawings.

#### 1.02 RELATED SECTIONS

- A. Section 260500 Common Work Results for Electrical
- B. Section 260519 Low Voltage Wire and Cable
- C. Section 260533 Raceway and Boxes
- D. Section 265100 Interior Lighting

#### 1.03 SUBMITTALS -- FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Architect/Engineer and Owner
  - 1. Manufacturer's product cut-sheet
- B. Submit electronically in PDF format.

#### 1.04 SUBMITTALS -- FOR INFORMATION

- A. When requested by the Engineer the following product information shall be submitted:
  - 1. Descriptive bulletins
  - 2. Product sheets.
- B. Submit electronically in PDF format.

#### 1.05 DELIVERY, STORAGE, AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

#### 1.06 OPERATION AND MAINTENANCE MANUALS

- A. One (1) paper copy and one (1) CD of the equipment operation and maintenance manuals shall be provided.
- B. Operation and maintenance manuals shall include the following information:
  - 1. Instruction books and/or leaflets
  - 2. Recommended renewal parts list
  - 3. Drawings and information required by section 1.06.

### PART 2 – PRODUCTS

#### 2.01 TIME CLOCK

- A. Manufacturers

1. Paragon

2. Tork

B. Ratings

1. Like Paragon Model EC71St-N3/120V Electronic Sun Tracker
2. 120 volt ac control voltage
3. Single Channel control
4. Contact Rating, 15 amp
5. NEMA 1 enclosure

2.02 PHOTOCONTROL

A. Manufacturers

1. Tork
2. Precision

B. Ratings

1. Weatherproof Lexan® housing
2. Photocell: 1 inch cadmium sulfide light sensitive element.
3. Turn on: 1 to 3 foot-candles. External light level slide allows field adjustment between 3 to 10 foot-candles.
4. Turn on / turn off ratio 1:3
5. Minimum 15 second time delay.
6. Single-pole, single-throw switch. Contact position at night normally closed.
7. Temperature Range -40 to 158 degree F
8. ½"-14 threaded stem.

2.03 LIGHTING CONTACTOR

A. Manufacturers

1. ASCO
2. Cutler Hammer
3. Square D

B. Ratings

1. 30 amp minimum
2. Number of poles as required
3. Control/coil voltage 120 volt
4. Electrical held
5. Installed in NEMA 1 enclosure or as required for location.

2.04 OCCUPANCY SENSORS

A. Wall Mounted

1. Wall Mounted occupancy sensors shall be a multi-technology (Ultrasonic & PIR) wall switch that turns lights on and off based upon occupancy and ambient light levels. Type 2 sensors shall contain two separate relays and manual override controls for dual level switching of light fixture. Sensors shall have built-in light level sensor, adjustable time delays, zero crossing switching, and smart technology. Provide necessary device box.

Type 1 sensors shall be Hubbell Building Automation #LHMTS1 or pre approved equal.  
Type 2 sensors shall be Hubbell Building Automation #LHMTD2 or pre approved equal.  
Color of devices shall be as selected by owner but generally shall match color of wiring devices.

B. Ceiling Mounted

1. Ceiling Mounted occupancy sensors, indicated by OS on plans, shall be a multi-technology (ultrasonic & PIR) sensor that turns lights on and off based upon occupancy. Sensor shall have adjustable time delays, zero crossing switching, and smart technology. Provide necessary back-box. Sensor shall be Hubbell Building Automation #OMNIDT2000 or pre approved equal.

C. Power Packs and Relays

1. The power packs shall provide both the 24VDC power supply to operate sensors as well as the 20-amp line voltage relay to control the load. Each power pack shall also contain an auxiliary relay contact, for use by others. Power pack shall be mounted to a junction box located above accessible ceiling. Housing shall be plenum rated. Power packs shall be Hubbell Building Automation #UVPP with model MPSA Auxiliary Relay Device or pre-approved equal.

2.05 WALL BOX DIMMERS

- A. Wall box dimmers shall be Leviton Renoir II series or approved equal.
- B. Shall be compatible with light fixture/driver and shall be capable of multi-location applications.

2.06 COMBINATION WALL BOX DIMMER AND OCCUPANCY SENSOR

- A. Wall box device providing both digital PIR occupancy sensor and 0-10V dimming shall be Hubbell LHDMIRS-3 series or approved equal.
- B. 3 buttons provide on/off, raise and lower light levels.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.
- B. Protect the equipment from damage and keep clean and dry during construction.
- C. Installation of in wall switch replacement occupancy sensors must be approved by the Owner.
- D. Install power packs above accessible ceilings and locate near door to room. If space has no ceiling, install power pack within a minimum 4" square junction box and locate near the door to the room, as neatly as possible. Coordinate with manufacturer.

END OF SECTION 260923

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## SECTION 262213 – DRY-TYPE DISTRIBUTION TRANSFORMERS – GENERAL PURPOSE

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install three-phase general purpose individually mounted dry-type transformers of the two-windings type, self-cooled as specified herein, and as shown on the contract drawings.

#### 1.02 RELATED SECTIONS

- A. Section 260500

#### 1.03 REFERENCES

- A. The transformers and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.

#### 1.04 SUBMITTALS -- FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:

1. Dimension drawing and weight
2. Technical certification sheet
3. Conduit entry/exit locations
4. Transformer ratings including:
  - a. Primary and secondary kVA
  - b. Voltage
  - c. Taps
  - d. Primary and secondary continuous current
  - e. Basic Impulse level for equipment over 600-volts
  - f. Impedance
  - g. Insulation class and temperature rise
  - h. Sound level.

- B. Submit electronically in PDF format.

#### 1.05 SUBMITTALS -- FOR INFORMATION

- A. When requested by the Engineer the following product information shall be submitted:

1. Descriptive bulletins
2. Product sheets.

- B. Submit electronically in PDF format.

#### 1.06 SUBMITTALS -- FOR CLOSEOUT

- A. The following information shall be submitted for record purposes.

- a. Final as-built drawings and information for items listed section 1.04

- b. Connection diagrams
  - c. Certified production test reports
  - d. Installation information
  - e. Seismic certification and equipment anchorage details.
- B. Submit one paper copy and one (1) CD of the above information.

#### 1.07 QUALIFICATIONS

- A. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.
- B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- C. The transformers shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC). Guidelines for the installation consistent with these requirements shall be provided by the transformer manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 0.75g, and a ZPA of 0.38g. The tests shall fully envelope this response spectrum for all equipment natural frequencies up to at least 35 Hz.

#### 1.08 REGULATORY REQUIREMENTS

- A. All transformers shall be UL listed and bear the UL label.

#### 1.09 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

#### 1.10 FIELD MEASUREMENTS

- A. Measure primary and secondary voltages and make appropriate tap adjustments.

#### 1.11 OPERATION AND MAINTENANCE MANUALS

- A. Three (3) copies of the equipment operation and maintenance manuals shall be provided.
- B. Operation and maintenance manuals shall include the following information:
- 1. Instruction books and/or leaflets
  - 2. Recommended renewal parts list
  - 3. Drawings and information required by section 1.06.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. Square D

- C. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

## 2.02 RATINGS

- A. kVA and voltage ratings shall be as shown on the drawings.
- B. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.
- C. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
- |                    |        |
|--------------------|--------|
| 1. Up to 9 kVA     | 40 db  |
| 2. 10 to 50 kVA    | 45 db  |
| 3. 51 to 150 kVA   | 50 db  |
| 4. 151 to 300 kVA  | 55 db  |
| 5. 301 to 500 kVA  | 60 db  |
| 6. 501 to 700 kVA  | 62 db  |
| 7. 701 to 1000 kVA | 64 db. |

## 2.03 CONSTRUCTION

- A. Insulation Systems
- Transformers shall be insulated as follows:
    - 15 kVA and above: 220 degrees C insulation system based upon 150 degree C rise
  - Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 degrees C maximum ambient.
  - All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.
- B. Core and Coil Assemblies
- Transformer core shall be constructed with high-grade, nonaging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade **copper** with continuous wound construction.
  - On units rated 30 kVA and the core and coil assembly shall be impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture.

The assembly shall be installed on vibration-absorbing pads. Taps shall be two (2) steps above and four (4) steps below nominal voltage in 2.5% increments.

#### 2.04 WIRING/TERMINATIONS

- A. Recommended external cable shall be rated 90 degrees C (sized at 75 degrees C ampacity) for encapsulated and 75 degrees C for ventilated designs. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.

#### 2.05 ENCLOSURE

- A. The enclosure shall be made of heavy-gauge steel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be grounded to the enclosure.
- B. On units rated 30 kVA and above the enclosure construction shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt.
- C. On outdoor units rated 30 kVA or above, provide suitable weathershields over ventilation openings.

#### 2.06 FINISH

- A. Enclosures shall be finished with ANSI 61 color weather-resistant enamel.

### PART 3 – EXECUTION

#### 3.01 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
  - 1. Ratio tests at the rated voltage connection and at all tap connections
  - 2. Polarity and phase relation tests on the rated voltage connection
  - 3. Applied potential tests
  - 4. Induced potential test
  - 5. No-load and excitation current at rated voltage on the rated voltage connection.
- B. The following special factory tests shall be performed on ratings above 500 kVA provided under this section. All tests shall be in accordance with the latest revision of ANSI and NEMA standards.
  - 1. Resistance measurements on all windings at the rated voltage connection of each unit and at the tap extremes of the first unit made of a new design.

#### 3.02 INSTALLATION

- A. Contractor shall install per the manufacturer's recommendations and the contract drawings.
- B. Transformers shall be installed on a minimum 3" high housekeeping pad

#### 3.03 FIELD QUALITY CONTROL

- A. During storage, transformers shall be protected from damage and kept clean, warm and dry.
- B. Prior to energizing the Contractor shall test transformer for shorts and grounds with a VOM

3.04 FIELD TESTING

- A. Megger primary and secondary windings for shorts and grounds.
- B. Measure primary and secondary voltages for proper tap settings

3.05 FIELD ADJUSTMENTS

- A. Adjust taps to deliver appropriate secondary voltage with no load.
- B. Retest voltage with full connected load energized and adjust taps to within 5% of rated voltage.
- C. The Owner shall witness the connected load test.

END OF SECTION 262213

## SECTION 262413 – SWITCHBOARDS – LOW VOLTAGE

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install, where indicated, a free-standing, deadfront type low voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the contract drawings.

#### 1.02 RELATED SECTIONS

- A. Section 262890 – Transient Voltage Surge Suppression

#### 1.03 REFERENCES

- A. The low voltage distribution switchboards and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards:
  - 1. NEMA PB-2
  - 2. UL Standard 891.

#### 1.04 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The Equipment Supplier shall provide a factory shop drawing review for up to three (3) Owner's Representatives. All costs, including transportation, lodging and meals, for this review shall be borne by the Equipment Supplier.
- B. The following information shall be available at the factory review:
  - 1. Master drawing index
  - 2. Front view elevation
  - 3. Floor plan
  - 4. Top view
  - 5. Single line
  - 6. Schematic diagram
  - 7. Nameplate schedule
  - 8. Component list
  - 9. Conduit entry/exit locations
  - 10. Assembly ratings including:
    - a. Short-circuit rating
    - b. Voltage
    - c. Continuous current
  - 11. Major component ratings including:
    - a. Voltage
    - b. Continuous current
    - c. Interrupting ratings

12. Cable terminal sizes

13. Product data sheets.

C. Where applicable, the following additional information shall be submitted to the Engineer:

1. Busway connection
2. Connection details between close-coupled assemblies
3. Composite floor plan of close-coupled assemblies
4. Key interlock scheme drawing and sequence of operations.

#### 1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in paragraph 1.04
2. Wiring diagrams
3. Certified production test reports
4. Installation information
5. Seismic certification and equipment anchorage details.

B. The final (as-built) drawings shall include the same drawings as the original construction drawings and shall incorporate all changes made during the manufacturing process.

#### 1.06 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the circuit protective devices within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g's (3.2-11 Hz), and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

E. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

#### 1.07 REGULATORY REQUIREMENTS

- A. The low-voltage switchboard shall be UL labeled.

#### 1.08 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

#### 1.09 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

#### 2.02 RATINGS

- A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current 65,000 amperes symmetrical at rated voltage.
- B. Voltage rating to be as indicated on the drawings.

#### 2.03 CONSTRUCTION

- A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.
- B. All sections of the switchboard shall be front and rear aligned with depth as shown on drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front and rear accessible. Rear access shall be provided.
- C. The assembly shall be provided with adequate lifting means.
- D. The switchboard shall be Cutler-Hammer type Pow-R-Line C utilizing the components herein specified and as shown on the drawings.

- E. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

#### 2.04 BUS

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on minimum 1000A per square inch of bus density
- B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.
- C. A copper ground bus (minimum 1/4 x 2 inch), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
- D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

#### 2.05 WIRING/TERMINATIONS

- A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
- B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.
- C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.
- D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

#### 2.06 POWER CIRCUIT BREAKERS MAIN AND TIE

- A. Protective devices shall be drawout low-voltage power air-circuit breakers, Cutler-Hammer type DSII or approved equal. Frame ratings shall be 800, 1600, 2000, 3200, 4000, or 5000 amperes. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
- B. Breakers shall be electrically operated (EO) as indicated on the drawings.
- C. Electrically operated breakers shall be complete with 120V AC operators, control switch, plus red and green LED indicating lights to indicate breaker contact position. AC source shall be taken from a control power transformer internal to the switchgear assembly.
- D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To assure a fully selective system, all circuit breakers shall have 30-cycle short-

- time withstand ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.
- E. Where circuit breakers are equipped with current limiters, the combination shall have short-time ratings in accordance with the characteristics of the limiter selected.
  - F. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.
  - G. Main and Tie power circuit breakers shall be provided with trip units.
  - H. For drawout applications the breaker cell shall be equipped with drawout rails and primary and secondary disconnecting contacts. The stationary part of the primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs.
    - 1. The secondary disconnecting devices shall consist of floating fingers mounted on the removable unit and engaging flat contact segments at the rear of the compartment. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the "connected" and "test" positions.
    - 2. The removable power circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for drawout application. It shall have four (4) positions: CONNECTED, TEST, DISCONNECTED, and REMOVED all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering "in" and "out" mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering "in" or "out" of the cell. The breaker shall include a provision for padlocking open to prevent manual or electric closing. The padlocking shall also secure the breaker in the connected, test or disconnected position by preventing levering.

## 2.07 TRIP UNITS

- A. Digitrip RMS 910

## 2.08 MOLDED CASE CIRCUIT BREAKERS – 1200A AND BELOW

- A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics and shall be Cutler-Hammer type Series C or approved equal.
- B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
- C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

- D. Circuit breakers 800 ampere frame and below shall be Cutler-Hammer type Series C with thermal-magnetic trip units and inverse time-current characteristics.
- E. Ground fault protection shall be provided where indicated.
- F. Where indicated provide UL listed circuit breakers for applications at 100% of their continuous ampere rating in their intended enclosure.

#### 2.09 MISCELLANEOUS DEVICES

- A. Key interlocks shall be provided as indicated on the drawings.
- B. Control power transformers with primary and secondary protection shall be provided, as indicated on the drawings, or as required for proper operation of the equipment. Control power transformers shall have adequate capacity to supply power to the transformer cooling fans.

#### 2.10 CUSTOMER METERING

- A. Microprocessor-Based Metering System
  - 1. PXM-2000 Series
- B. Current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.
- C. Fused potential taps as the potential source for metering as shown on the drawings.
- D. Ethernet/Web/BACNET IP communications.

#### 2.11 ENCLOSURES

- A. NEMA 1 Enclosure

#### 2.12 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.
- B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

#### 2.13 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

#### 2.14 TRANSIENT VOLTAGE SURGE SUPPRESSION

- A. Provide transient voltage surge suppression.

### PART 3 – EXECUTION

### 3.01 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
  - 1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground.
- B. The manufacturer shall provide three (3) certified copies of factory test reports.

### 3.02 MANUFACTURER'S CERTIFICATION

- A. A certified test report of all standard production tests shall be available to the Engineer upon request.

### 3.03 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's instructions, contract drawings and National Electrical Code.
- B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to either Contractor supplied floor sills or the floor level to 1/8 inch per 3-foot distance in any direction. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

### 3.04 FIELD ADJUSTMENTS

- A. A Manufacturer's Service Representative shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.
- B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with an approved short circuit and protective device coordination study shall be carried out by the Manufacturer's Service Representative at no additional cost to the Owner.
- C. Assist temperature controls contractor with BACNET IP connection to meter for monitoring energy usage.

END OF SECTION 262413

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## SECTION 262416 - PANELBOARDS

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install the panelboards as specified and as shown on the contract drawings.

#### 1.02 RELATED SECTIONS

- A. Section 261450 – Lighting Control System
- B. Section 262890 – Transient Voltage Surge Suppression

#### 1.03 REFERENCES

- A. The panelboards and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows:
  - 1. UL 67 – Panelboards
  - 2. UL 50 – Cabinets and boxes
  - 3. NEMA PB1
  - 4. Fed. Spec. W-P-115C
  - 5. Circuit breaker – Type I class I
  - 6. Fusible switch – Type II class I.

#### 1.04 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:
  - 1. Breaker layout drawing with dimensions indicated and nameplate designation
  - 2. Component list
  - 3. Conduit entry/exit locations
  - 4. Assembly ratings including:
    - a. Short-circuit rating
    - b. Voltage
    - c. Continuous current
  - 5. Cable terminal sizes
  - 6. Product data sheets.

#### 1.05 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:
  - 1. Final as-built drawings and information for items listed in paragraph 1.04
  - 2. Installation information
  - 3. Seismic certification and equipment anchorage details.

- B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

#### 1.06 QUALIFICATIONS

- A. The manufacturer of the panelboard shall be the manufacturer of the major components within the assembly, including circuit breakers and fusible switches.
- B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g's (3.2–11 Hz), and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.
- E. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
  - 1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.
  - 2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
  - 3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

#### 1.07 REGULATORY REQUIREMENTS

- A. The panelboards shall be UL labeled.

#### 1.08 DELIVERY, STORAGE, AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

#### 1.09 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

## PART 2 – PRODUCTS

### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. Square D
- C. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

### 2.02 RATINGS

- A. Panelboards rated 240V AC or less shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 22,000 amperes RMS symmetrical.
- B. Panelboards rated 480V AC shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 65,000 amperes RMS symmetrical.
- C. Panelboards shall be labeled with a UL short-circuit rating. When series ratings are applied with integral or remote upstream devices, a label or manual shall be provided. It shall state the conditions of the UL series ratings including:
  - 1. Size and type of upstream device
  - 2. Branch devices that can be used
  - 3. UL series short-circuit rating.

### 2.03 CONSTRUCTION

- A. Interiors shall be completely factory assembled devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
- B. Trims for branch circuit panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi flush cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners.
- C. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible.
- D. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.

- E. A directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.
- F. All locks shall be keyed alike.

#### 2.04 BUS

- A. Main bus bars shall be copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
- B. A system ground bus shall be included in all panels.
- C. Full-size (100%-rated) insulated neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection. 200%-rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.

#### 2.05 BRANCH CIRCUIT PANELBOARDS

- A. The minimum short-circuit rating for branch circuit panelboards shall be as specified herein or as indicated on the drawings. Panelboards shall be fully rated. Panelboards shall be like Cutler-Hammer type Pow-R-Line 1a, Pow-R-Line 2a or Pow-R-Line 3a.
- B. Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.
- C. Circuit breakers shall be thermal-magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100-ampere frame and through 100-ampere trip sizes shall take up the same pole spacing. Circuit breakers shall be UL listed as type SWD for lighting circuits.
  - 1. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management, and control system (EMCS) panels and fire alarm panels.
- D. Circuit breakers shall have a minimum interrupting rating of 22,000 amperes symmetrical at 240 volts, and 42,000 amperes symmetrical at 480 volts, unless otherwise noted on the drawings.

#### 2.06 DISTRIBUTION PANELBOARDS – CIRCUIT BREAKER TYPE

- A. Distribution panelboards with bolt-on devices contained therein shall have interrupting ratings as specified herein or indicated on the drawings. Panelboards shall be fully rated Panelboards and shall be like Cutler-Hammer type Pow-R Line 3a or Pow-R-Line 4B. Panelboards shall have molded case circuit breakers as indicated below.
- B. Where indicated, provide circuit breakers UL listed for application at 100% of their continuous ampere rating in their intended enclosure.
- C. Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.

#### 2.07 ENCLOSURE

- A. Enclosures shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
- B. Enclosures shall be provided with blank ends.
- C. Where indicated on the drawings, branch circuit panelboards shall be column width type.

#### 2.08 NAMEPLATES

- A. Provide an engraved nameplate for each panel section.
- B. Owner shall provide label information

#### 2.09 FINISH

- A. Surfaces of the trim assembly shall be properly cleaned, primed, and a finish coat of gray ANSI 61 paint applied.

### PART 3 – EXECUTION

#### 3.01 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

#### 3.02 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.

#### 3.03 QUALITY CONTROL

- A. Prior to energizing the Contractor shall:
  - 1. Torque all connections per the Manufacturer's recommendations.
  - 2. With a 1000 volt Megger test all phase and neutral bus for shorts and grounds.

END OF SECTION 262416

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## SECTION 262726 – WIRING DEVICES

### PART 1 – GENERAL

#### 1.01 DESCRIPTION OF WORK

- A. Types and locations of wiring devices are indicated by the Project drawings.
- B. Types of wiring devices in this section include the following
  - 1. Receptacles
  - 2. Switches
  - 3. Cover plates

#### 1.02 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of wiring devices, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installers: Firm with at least five (5) years of successful installation experience with projects utilizing wiring device work similar to those required for this Project.
- C. NEC Compliance: Comply with NEC requirements as applicable to construction, installation and coding of wiring devices.
- D. UL Labels: Provide wiring devices that are UL listed and labeled.

#### 1.03 DELIVERY, STORAGE AND HANDLING

- A. Deliver wiring devices properly packaged in factory-fabricated type containers.
- B. Store wiring devices in a clean dry space. Protect products from weather, damaging fumes, construction debris and traffic.

### PART 2 – PRODUCTS

#### 2.01 GENERAL

- A. General use receptacles shall be heavy-duty duplex 2 pole 3 wire grounding type unless loads require 20 amp.
- B. All switches shall be specification grade quiet switches, 120-277 volt 15 amp.
- C. Device colors shall be as selected by the Owner but generally all devices shall be white on painted walls and brown on wood walls unless for special application.
- D. Devices on emergency circuits shall be red.
- E. All exterior receptacles and any receptacle within six (6) feet of any water shall be GFCI.

#### 2.02 MANUFACTURERS AND CATALOG NUMBERS

- A. Hubbell, Bryant, Arrow Hart, Leviton and Pass & Seymour are the only acceptable manufacturers.
- B. The following is an approved list of receptacles by type (based on Hubbell).
  - 1. 20 amp duplex- # HBL5362 or approved equal
  - 2. 20 amp isolated ground- #IG5362 (orange) or approved equal

3. 20 amp single- # HBL5361 or approved equal
  4. 20 amp GFCI - # GF5362 or approved equal
  5. 20 amp USB - USB20AC5 series
- C. The following is the approved list of switches by type (based on Hubbell).
1. Single pole toggle switch-# HBL1201 or approved equal
  2. 2 pole toggle switch - # HBL1202 or approved equal
  3. 3-way toggle switch-# HBL1203 or approved equal
  4. 4-way toggle switch- # HBL1204 or approved equal
- D. All interior device cover plates are to be nylon (plastic not allowed), color to match device color unless otherwise noted.
- E. Unless otherwise directed, device colors shall closely match the paint color of the surface they are mounted to, typically ivory or brown. Coordinate in field and with architect.
- F. All exterior device cover plates shall be weatherproof type unless otherwise noted.
- G. Electronic digital time switches – adjustable from 5 minutes to 12 hours, set at 4 hours. Flash and audible warning prior to shut off. Backlit LCD display. Capable of multi-location applications. Wattstopper #TS-400 series.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION OF WIRING DEVICES

- A. General: Install wiring devices as indicated, in compliance with applicable requirements of NEC, NEMA, UL and NECA's "Standard of Installations", and in accordance with recognized industry practices.
- B. Install all wiring in approved boxes or enclosures.
- C. For vertically install receptacles install with ground up and on horizontal receptacles the ground on the left.
- D. Verify proper orientation of all switches
- E. Cover plates must cover all openings around devices and boxes.
- F. All devices must be installed plumb with the surroundings
- G. All device cover plate screws slots shall be vertical.

END OF SECTION 262726

## SECTION 262816 – SAFETY SWITCHES

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install the low-voltage fused and non-fused switches as specified herein and as shown on the contract drawings.

#### 1.02 REFERENCES

- A. The switches and all components shall be designed, manufactured and tested in accordance with the latest applicable standards:
  - 1. NEMA KS-1
  - 2. UL 98

#### 1.03 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:
  - 1. Dimensioned outline drawing
  - 2. Conduit entry/exit locations
  - 3. Switch ratings including:
    - a. Short-circuit rating
    - b. Voltage
    - c. Continuous current
  - 4. Fuse ratings and type
  - 5. Cable terminal sizes
  - 6. Product data sheets

#### 1.04 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:
  - 1. Final as-built drawings and information for items listed in paragraph 1.04

#### 1.05 QUALIFICATIONS

- A. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

#### 1.06 REGULATORY REQUIREMENTS

- A. The safety switches shall bear a UL label.

#### 1.07 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. Square D

- C. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

## 2.02 GENERAL DUTY SAFETY SWITCHES

- A. Provide switches as shown on drawings with the following ratings:

1. 30 to 600 amperes
2. 240 volts AC maximum
3. 2 and 3-pole plus S/N
4. Fusible and non-fusible
5. Mechanical lugs suitable for aluminum or copper conductors.

- B. Construction

1. Switch blades and jaws shall be visible and plated copper.
2. Switches shall have a black handle through 100A (except on plug-fuse type) that is easily padlockable with two 3/8-inch shank locks in the OFF position. Higher rating shall have a red handle that is easily padlockable with three 3/8-inch shank locks in the OFF position.
3. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position.
4. Switch assembly and operating handle shall be an integral part of the enclosure.
5. Switches rated 100A to 600A shall have reinforced fuse clips.
6. Switch blades shall be readily visible in the ON and OFF position.
7. Switch operating mechanism shall be non-teasable, positive quick-make/quick-break type (except 30A plug-fuse type).
8. Fusible switches shall be suitable for service entrance equipment and be equipped with factory installed neutrals.
9. All switches (except 30A plug-fuse type) shall have side opening doors. Door padlocking capability shall be provided.
10. Suitable for systems capable of 100kA with Class R Fuses (except 30A plug-fuse type).
11. Double-make, double-break switch blade feature shall be provided (except 30A plug-fuse type).
12. 30A to 100A shall have R fuse rejection capability (not applicable to plug-fuse type).
13. All switches shall be manufactured in the USA.

- C. Enclosures

1. All enclosures shall be NEMA 1 general purpose unless otherwise noted.
2. Other types, where noted, shall be:
  - a. NEMA 3R rainproof
  - b. NEMA 1 plug fuse indoor
3. Paint color shall be ANSI 61 gray.

4. 30A to 60A NEMA 1 enclosures shall have tangential knockouts on the top, bottom, and sides of the enclosure. NEMA 3R enclosures shall have tangential knockouts on the bottom and sides. (Not applicable to NEMA 1 plug-fuse type).

## 2.03 HEAVY-DUTY SAFETY SWITCHES

### A. Provide switches as shown on drawings, with the following ratings:

1. 30 to 1200 amperes
2. 250 volts AC, DC; 600 volts AC (30A to 200A 600 volts DC)
3. 2, 3, 4, and 6 poles
4. Fusible and non-fusible
5. Mechanical lugs suitable for aluminum or copper conductors.

### B. Construction

1. Switch blades and jaws shall be visible and plated copper.
2. Switches shall have a red handle that is easily padlockable with three 3/8-inch shank locks in the OFF position.
3. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position. Defeater mechanism shall be front accessible.
4. Switch assembly and operating handle shall be an integral part of the enclosure base.
5. Switches rated 30A to 600A shall have reinforced fuse clips.
6. Switch blades shall be readily visible in the ON and OFF position.
7. Switch operating mechanism shall be non-teasable, positive quick-make/quick-break type. Bail type mechanisms are not acceptable.
8. Fusible switches shall be suitable for service entrance equipment.
9. Switches shall have line terminal shields.
10. Suitable for systems capable of 200 kA at 480V with Class J, L, R, or T fusing as applicable.
11. Embossed or engraved ON-OFF indication shall be provided.
12. Double-make, double-break switch blade feature shall be provided.
13. Fuse pullers shall be provided on all NEMA 4X and 12 switches through 200A.
14. Renewal parts data shall be shown on the inside of the door.
15. All switches shall be manufactured in the USA.

### C. Enclosures

1. All enclosures shall be NEMA 1 general purpose unless otherwise noted.
2. Other types, where noted, shall be:
  - a. NEMA 3R rainproof
  - b. NEMA 4 watertight (800A max.)
  - c. 30A to 200A – 304 stainless steel

- d. 400A to 800A – 304 stainless steel
- e. NEMA 12 dust-tight and oil-tight special industry (800A max.).
- 3. Paint color shall be ANSI 61 gray.
- 4. 30A to 100A NEMA 4, 4X, and 12 enclosures shall be provided with draw-pull latches.

D. The following factory modifications are to be included:

- 1. Phenolic nameplates
- 2. Class R fuse clips factory installed

#### 2.04 NAMEPLATES

- A. Nameplate shall be front cover mounted, containing a permanent record of switch type, ampere rating, and maximum voltage rating.

### PART 3 – EXECUTION

#### 3.01 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

#### 3.02 INSTALLATION

- A. The equipment shall be installed per the manufacturer's recommendations.

END OF SECTION 262816

## SECTION 262913 – ENCLOSED MOTOR STARTERS

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install the low voltage motor starters as specified herein and as shown on the contract drawings.

#### 1.02 REFERENCES

- A. The motor starters shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, ANSI and UL.

#### 1.03 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Dimensioned outline drawings
3. Conduit entry/exit locations
4. Cable terminal sizes
5. Wiring diagrams
6. Nameplate schedule
7. Ratings including:
  - a. Voltage
  - b. Horsepower and/or continuous current
8. Product data sheets.

#### 1.04 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in paragraph 1.04
2. Wiring diagrams
3. Seismic certification.

- B. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

#### 1.05 QUALIFICATIONS

- A. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
- B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for Zone 4 application. Guidelines for

the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g's (3.2–11 Hz), and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

- D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.
  2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
  3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

#### 1.06 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. Square D
- C. Allen Bradley
- D. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

#### 2.02 MANUAL MOTOR CONTROL

- A. Single-Phase Manual Starters
1. Manual single-phase starters 1 hp or smaller shall be Cutler-Hammer type MS starters or approved equal. The starter shall have a quick-make/quick-break toggle mechanism. The overload shall have a field adjustment allowing up to +/- 10% variance in ratings of the nominal heater value.
  2. Manual single-phase starters above 1 hp shall be Cutler-Hammer type B100 or approved equal. The starter shall have quick-make/quick-break mechanism. The closure of the contacts shall be blocked while the line terminals are exposed. The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED.

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3. The enclosure shall be as indicated on the contact drawings.

B. Three-Phase Manual Starters

1. The starter shall have quick-make/quick-break operating mechanism
2. The operating handle or button shall clearly indicate whether the unit is ON, OFF or TRIPPED.
3. The closure of the contacts shall be blocked while the line terminals are exposed.
4. The enclosure shall be as indicated on the contract drawings.
5. Manual three-phase motor starters shall be Cutler-Hammer type B100 or equal.

C. Three-Phase Manual Motor Starter and Protector

1. The starter shall have an adjustable Class 10 ambient compensated integral overload relay and a fixed magnetic short-circuit trip mechanism designed to trip at twelve (12) times the maximum current rating of the starter.
2. The starter shall be UL listed and CSA certified for group motor installations with 1200 ampere maximum fuse and circuit breaker ratings at 480V AC.
3. The starter shall have provisions for padlocking in the OFF position.
4. The starter shall have accessories such as auxiliary contacts, trip alarm, undervoltage release, and shunt trip available for field installation.
5. The enclosure shall be general purpose NEMA 1.
6. Motor starter and protector shall be Cutler-Hammer type A302 or equal.

2.03 ELECTROMECHANICAL MOTOR CONTROL

A. Non-Reversing Starters

1. Magnetic starters through NEMA Size 9 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring. Each starter shall have one (1) NO auxiliary contact.
2. Coils shall be of molded construction through NEMA Size 9. All coils to be color-coded through Size 5 and permanently marked with voltage, frequency and part number.
3. Solid-State Overload Relay
  - a. Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler Hammer type CEP7 or approved equal.
  - b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
  - c. The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
  - d. The overload relay shall have the following features:
    - 1) Be self-powered
    - 2) Class 10 or 20 fixed tripping characteristics
    - 3) Manual or automatic reset

- 4) Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
  - 5) Visible trip indication
  - 6) One NO and one NC isolated auxiliary contact
  - 7) Test button that operates the normally closed contact
  - 8) Test trip function that trips both the NO and NC contacts
  - 9) A current adjustment range of 3.2:1 or greater
  - 10) Ambient temperature compensated
  - 11) Ground fault protection. Relay shall trip at 50% of full load ampere setting
  - 12) Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush.
4. NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any arrangement normally open or normally closed. Size 3 through 8 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any arrangement normally open or normally closed.
  5. Motor starters shall be Cutler-Hammer Freedom Series or approved equal.
- B. Reversing Starters
1. Reversing starters shall consist of two (2) contactors and a single overload relay assembled together. The contactors shall be mechanically and electrically interlocked to prevent line shorts and the energizing of both contactors simultaneously.
  2. Magnetic starters through NEMA Size 8 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring.
  3. Coils shall be of molded construction through NEMA Size 8. All coils to be color-coded through Size 5 and permanently marked with voltage, frequency and part number.
  4. Solid-State Overload Relay
    - a. Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler Hammer type CEP7 or approved equal.
    - b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
    - c. The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
    - d. The overload relay shall have the following features:
      - 1) Be self-powered
      - 2) Class 10 or 20 fixed tripping characteristics
      - 3) Manual or automatic reset
      - 4) Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
      - 5) Visible trip indication

- 6) One NO and one NC isolated auxiliary contact
  - 7) Test button that operates the normally closed contact
  - 8) Test trip function that trips both the NO and NC contacts
  - 9) A current adjustment range of 3.2:1 or greater
  - 10) Ambient temperature compensated
  - 11) Ground fault protection. Relay shall trip at 50% of full load ampere setting
  - 12) Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush.
5. NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any arrangement normally open or normally closed. Sizes 3 through 8 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any arrangement normally open or normally closed.
6. Motor starters shall be Cutler-Hammer Freedom Series or approved equal.
- C. Two-Speed Starters
1. Magnetic starters through NEMA Size 6 shall be equipped with double-break silver alloy contacts. The starter must have straight-through wiring.
  2. Coils shall be of molded construction through NEMA Size 6. All coils to be color-coded through Size 5 and permanently marked with voltage, frequency and part number.
  3. Solid State Overload Relay
    - a. Provide a solid-state overload relay for protection of the motors. The relay shall be Cutler Hammer type CEP7 or approved equal.
    - b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.
    - c. The overload relay shall be modular in design, be an integral part of a family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.
    - d. The overload relay shall have the following features:
      - 1) Be self-powered
      - 2) Class 10 or 20 fixed tripping characteristics
      - 3) Manual or automatic reset
      - 4) Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor
      - 5) Visible trip indication
      - 6) One NO and one NC isolated auxiliary contact
      - 7) Test button that operates the normally closed contact
      - 8) Test trip function that trips both the NO and NC contacts
      - 9) A current adjustment range of 3.2:1 or greater
      - 10) Ambient temperature compensated
      - 11) Ground fault protection. Relay shall trip at 50% of full load ampere setting

12) Jam/Stall protection. Relay shall trip at 400% of full load ampere setting, after inrush.

4. NEMA Size 00 through 2 starters shall be suitable for the addition of at least six (6) external auxiliary contacts of any combination of normally open or normally closed contacts. Sizes 3 through 6 starters shall be suitable for the addition of up to eight (8) external auxiliary contacts of any combination of normally open or normally closed contacts.
5. Two-speed magnetic starters for motors up to 400 hp, 600 volts shall be Cutler-Hammer Freedom Series type AN700 or approved equal.

#### 2.04 ELECTROMECHANICAL REDUCED VOLTAGE MOTOR CONTROL

##### A. Autotransformer Type

1. The starter shall utilize an autotransformer for a reduced voltage start. The autotransformer shall have adjustable voltage taps at 50%, 65% and 80%
2. The starter shall be an open transition type
3. The autotransformer shall use electromechanical type starters.

##### B. Part-Winding Type

1. The starter shall utilize a part winding connection for a reduced voltage start.
2. The starter shall be an open transition type.
3. The part-winding starter shall use electromechanical type starters.

##### C. Wye-Delta Type

1. The starter shall utilize a wye-delta connection for a reduced voltage start.
2. The starter shall be an open transition type.
3. The wye-delta starter shall use electromechanical type starters.

#### 2.05 ENCLOSURES

- A. The enclosure shall be as indicated on the contract drawings.
- B. Starters shall have an adjustable instantaneous motor circuit protector (HMCP) type disconnect device.

#### 2.06 OPTIONS

- A. Each starter shall be equipped with a fused control power transformer (100 VA minimum)
- B. HOA selector switch
- C. Red LED "run" pilot light
- D. 2 NO/2 NC auxiliary contacts

### PART 3 – EXECUTION

#### 3.01 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.

- B. The manufacturer shall provide certified copies of factory test reports in PDF Format.

END OF SECTION 262913

## SECTION 262933 – AFD

### PART 1 – GENERAL

#### 1.01 SECTION INCLUDES

- A. Adjustable Frequency Drives (AFDs)

#### 1.02 RELATED WORK

#### 1.03 REFERENCES

- A. UL 508
- B. NEC

#### 1.04 QUALITY ASSURANCE

- A. To ensure quality and minimize infantile failures at the jobsite, the complete AFD shall be tested by the manufacturer. The AFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
- B. All optional features shall be functionally tested at the factory for proper operation.

#### 1.05 SUBMITTALS

- A. Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, AFD's FLA rating, certification agency file numbers and catalog information.
- B. The specification lists the minimum AFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.
- C. Harmonic filtering. The seller shall, with the aid of the buyer's electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Danfoss Graham VLT HVAC Series
- B. No substitutions, campus standard

#### 2.02 GENERAL

- A. Furnish complete variable frequency AFDs as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the AFD enclosure, unless otherwise specified. AFD shall be housed in a metal NEMA 1 enclosure, or other NEMA type according to the installation and operating conditions at the job site. The AFD's UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated AFD.
- B. The AFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current

shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.

- C. With the motor's rated voltage applied to the AFD input, the AFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. AFDs utilizing sine weighted/coded modulation (with or without 3<sup>rd</sup> harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.
- D. The AFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- E. The AFD and options shall be tested to ANSI/UL Standard 508. The complete AFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the AFD and option panel, in the case where these are not contained in one panel. When these AFDs are to be located in Canada, CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.
- F. The AFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. AFDs without DC link reactors shall provide a minimum 3% impedance line reactor.
- G. The AFD's full load amp rating shall meet or exceed NEC Table 430-150. The AFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- H. The AFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- I. An automatic energy optimization selection feature shall be provided standard in the AFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- J. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the AFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- K. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- L. Galvanic and/or optical isolation shall be provided between the AFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. AFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
- M. AFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and AFD efficiencies while reducing motor noise.

## 2.03 PROTECTIVE FEATURES

- A. A minimum of Class 20 I<sup>2</sup>t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.

- B. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, AFD overtemperature and motor overtemperature. The AFD shall display all faults in plain English. Codes are not acceptable.
- C. Protect AFD from sustained power or phase loss. The AFD shall provide full rated output with an input voltage as low as 90% of the nominal. The AFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units, and 313 V AC for 460 volt units.
- D. The AFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
- E. AFD package shall include semi-conductor rated input fuses to protect power components.
- F. To prevent breakdown of the motor winding insulation, the AFD shall be designed to comply with IEC Part 34-17. Otherwise the AFD manufacturer must ensure that inverter rated motors are supplied.
- G. AFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
- H. AFD shall function normally when the keypad is removed while the AFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
- I. AFD shall catch a rotating motor operating forward or reverse up to full speed.
- J. AFD shall be rated for 100,000 amp interrupting capacity (AIC).
- K. AFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The AFD will identify which of the output phases is low or lost.
- L. AFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt VFDs, and 539 V AC on 460 volt AFDs.

#### 2.04 INTERFACE FEATURES

- A. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the AFD and determine the speed reference.
- B. The AFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the AFD is in Auto/Remote mode.
- C. The AFD shall provide digital manual speed control. Potentiometers are not acceptable.
- D. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
- E. The keypads for all sizes of AFDs shall be identical and interchangeable.
- F. To set up multiple AFDs, it shall be possible to upload all setup parameters to the AFD's keypad, place that keypad on all other AFDs in turn and download the setup parameters to each AFD. To facilitate setting up AFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
- G. Display shall be programmable to display in 9 languages including English, Spanish and French.
- H. The display shall have four lines, with 20 characters on three lines and eight large characters on one line.

- I. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the AFD when the keypad is removed.
- J. A quick setup menu with factory preset typical HVAC parameters shall be provided on the AFD eliminating the need for macros.
- K. The AFD shall include a standard RS-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2 Metasys or Siemens FLN system at no additional cost to the owner. The connection shall be software selectable by the user.
- L. The AFD, when furnished with a Bypass shall include a common Start/Stop relay to allow the unit operation to be controlled by the Temperature Control Contractor or time clock when operating in either the Drive or Bypass modes.
- M. As a minimum, the following points shall be controlled and/or accessible:
  - 1. AFD Start/Stop
  - 2. Speed reference
  - 3. Fault diagnostics
  - 4. Meter points
    - a. Motor power in HP
    - b. Motor power in kW
    - c. Motor kW-hr
    - d. Motor current
    - e. Motor voltage
    - f. Hours run
    - g. Feedback signal #1
    - h. Feedback signal #2
    - i. DC link voltage
    - j. Thermal load on motor
    - k. Thermal load on AFD
    - l. Heatsink temperature
- N. Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the AFD.
- O. LonWorks communication shall be available for factory or field installation within the AFD.
- P. Two set-point control interface (PID control) shall be standard in the unit. AFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
- Q. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
- R. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. AFDs unable to show these four displays simultaneously shall provide panel meters.
- S. Sleep mode shall be provided to automatically stop the AFD when its speed drops below set "sleep" level for a specified time. The AFD shall automatically restart when the speed command exceeds the set "wake" level.
- T. The sleep mode shall be functional in both follower mode and PID mode.

- U. Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the AFD does not start until dampers or other auxiliary equipment are in the proper state for AFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the AFD to start.
- V. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, AFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). AFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.
- W. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.
- X. AFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- Y. If the temperature of the AFD's heat sink rises to 80°C, the AFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the AFD shall automatically reduce its output frequency to the motor. As the AFD's heat sink temperature returns to normal, the AFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- Z. The AFD shall have temperature controlled cooling fans for quiet operation and minimized losses.
- AA. The AFD shall store in memory the last 10 faults and related operational data.
- BB. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- CC. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of AFD status.
- DD. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
- EE. Two programmable 0 to 20 mA analog outputs shall be provided for indication of AFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.
- FF. Under fire mode conditions, the AFD shall be able to be programmed to automatically default to a preset speed.

## 2.05 ADJUSTMENTS

- A. AFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.
- B. Sixteen preset speeds shall be provided.
- C. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
- D. Four current limit settings shall be provided.
- E. If the AFD trips on one of the following conditions, the AFD shall be programmable for automatic or manual reset: undervoltage, overvoltage, current limit and inverter overload.

F. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

G. An automatic "on delay" may be selected from 0 to 120 seconds.

#### 2.06 BYPASS

A. Provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the AFD. In the OFF position, the motor and AFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the AFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the AFD. This allows the AFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode. Bypass shall be furnished with an Undervoltage relay.

B. Service personnel shall be able to defeat the main power disconnect and open the bypass enclosure without disconnecting power. This shall be accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.

#### 2.07 SERVICE CONDITIONS

A. Ambient temperature, -10 to 40°C (14 to 104°F).

B. 0 to 95% relative humidity, non-condensing.

C. Elevation to 3,300 feet without derating.

D. AC line voltage variation, -10 to +10% of nominal with full output.

E. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

### PART 3 – EXECUTION

#### 3.01 START-UP SERVICE

A. The manufacturer shall provide start-up commissioning of the AFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the AFD, its options and its interface wiring to the building automation system.

#### 3.02 WARRANTY

A. The AFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service.

#### 3.03 EXAMINATION

A. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for AFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.

- B. The AFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The AFD shall not be operated while the unit is covered.

END OF SECTION 262933

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## SECTION 263623 – AUTOMATIC TRANSFER SWITCH

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. Furnish and install automatic transfer switches (ATS) with number of poles, amperage, voltage, and withstand current ratings as shown on the plans. Each automatic transfer shall consist of an inherently double throw power transfer switch unit and a microprocessor controller, interconnected to provide complete automatic operation. All transfer switches and control panels shall be the product of the same manufacturer.

#### 1.02 CODES AND STANDARDS

- A. The automatic transfer switches and accessories shall conform to the requirements of:
  - 1. UL 1008 - Standard for Automatic Transfer Switches
  - 2. NFPA 70 - National Electrical Code
  - 3. NFPA 110 - Emergency and Standby Power Systems
  - 4. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
  - 5. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
  - 6. NEC Articles 700, 701, 702
  - 7. International Standards Organization ISO 9001: 2000

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Acceptable Manufacturers
  - 1. ASCO
  - 2. Onan-Cummins Power
  - 3. Others must submit for approval

#### 2.02 MECHANICALLY HELD TRANSFER SWITCH

- A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include overcurrent disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible positions, normal or emergency.
- B. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.
- C. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts.
- D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at any point throughout their entire travel to inspect and service the contacts when required.

- E. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.
- F. Neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated Copper pressure connectors shall be provided.

## 2.03 MICROPROCESSOR CONTROLLER WITH MEMBRANE INTERFACE PANEL

- A. The controller shall direct the operation of the transfer switch. The controller's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent serial communications capability. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.
- B. The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers.
- C. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:
  1. ANSI C37.90A/IEEE 472 Voltage Surge Test
  2. NEMA ICS – 109.21 Impulse Withstand Test
  3. IEC801-2 Electrostatic discharge (ESD) immunity
  4. ENV50140 and IEC 801 – 3 Radiated electromagnetic field immunity
  5. IEC 801 – 4 Electrical fast transient (EFT) immunity
  6. ENV50142 Surge transient immunity
  7. ENV50141: Conducted radio-frequency field immunity
  8. EN55011: Group 1, Class A conducted and radiated emissions
  9. EN61000 –4 – 11 Voltage dips and interruptions immunity

## 2.04 ADDITIONAL REQUIREMENTS

- A. The ATS shall be rated to close on and withstand the available rms symmetrical short circuit current at the ATS terminals with the type of overcurrent protection shown on the plans. WCR ATS ratings as be as follows when used with specific circuit breakers:

ATS Size	Withstand & Closing Rating MCCB	W/CLF
30	22,000A	100,000
70 - 200	22,000A	200,000
230	22,000A	100,000
260 – 400	42,000A	200,000
600 – 1200	65,000A	200,000

1600 – 2000	85,000A	200,000
2600 – 3000	100,000A	200,000

## 2.05 ENCLOSURE

- A. The ATS shall be furnished in a NEMA type 1 enclosure unless otherwise shown on the plans.
- B. Controller shall be flush-mounted display with LED indicators for switch position and source acceptability. It shall also include test and time delay bypass switches.

## PART 3 – OPERATION

### 3.01 VOLTAGE AND FREQUENCY SENSING

- A. The voltage of each phase of the normal source shall be monitored, with pickup adjustable to 95% of nominal and dropout adjustable from 70% to 90% of pickup setting.
- B. Single-phase voltage and frequency sensing of the emergency source shall be provided.

### 3.02 TIME DELAYS

- A. An adjustable time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.
- B. An adjustable time delay shall be provided on transfer to emergency, adjustable from 0 to 5 minutes for controlled timing of transfer of loads to emergency.
- C. A generator stabilization time delay shall be provided after transfer to emergency.
- D. An adjustable time delay shall be provided on retransfer to normal, adjustable to 30 minutes. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.
- E. A 5-minute cooldown time delay shall be provided on shutdown of engine generator.
- F. All adjustable time delays shall be field adjustable without the use of special tools.

### 3.03 ADDITIONAL FEATURES

- A. A set of contacts rated 5 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
- B. A push-button type test switch shall be provided to simulate a normal source failure.
- C. A push-button type switch to bypass the time delay on transfer to emergency, the engine exerciser period on the retransfer to normal time delay whichever delay is active at the time the push-button is activated.
- D. Terminals shall be provided for a remote contact which opens to signal the ATS to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal.
- E. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of one contact, closed when the ATS is connected to the normal source and one contact, closed, when the ATS is connected to the emergency source.

- F. Indicating lights shall be provided, one to indicate when the ATS is connected to the normal source (green) and one to indicate when the ATS is connected to the emergency source (red). Also provide indicating lights for both normal and emergency source availability.
- G. Terminals shall be provided to indicate actual availability of the normal and emergency sources, as determined by the voltage sensing pickup and dropout settings for each source.
- H. Engine Exerciser - An engine generator exercising timer shall be provided, including a selector switch to select exercise with or without load transfer.
- I. Inphase Monitor - An Inphase monitor shall be inherently built into the controls. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The inphase monitor shall be specifically designed for and be the product of the ATS manufacturer.
- J. Selective Load Disconnect - A double throw contact shall be provided to operate after a time delay, adjustable to 20 seconds prior to transfer and reset 0 to 20 seconds after transfer. This contact can be used to selectively disconnect specific load(s) when the transfer switch is transferred. Output contacts shall be rated 6 amps at 28 VDC or 120 VAC.

#### 3.04 TESTS AND CERTIFICATION

- A. The complete ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
- B. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
- C. The ATS manufacturer shall be certified to ISO 9001: 2000 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001: 2000.

#### 3.05 SERVICE REPRESENTATION

- A. The ATS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
- B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.
- C. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.

END OF SECTION 263623

## SECTION 262413 – SWITCHBOARDS – LOW VOLTAGE

### PART 1 – GENERAL

#### 1.01 SCOPE

- A. The Contractor shall furnish and install, where indicated, a free-standing, deadfront type low voltage distribution switchboard, utilizing group mounted circuit protective devices as specified herein, and as shown on the contract drawings.

#### 1.02 RELATED SECTIONS

- A. Section 262890 – Transient Voltage Surge Suppression

#### 1.03 REFERENCES

- A. The low voltage distribution switchboards and all components shall be designed, manufactured and tested in accordance with the latest applicable following standards:

- 1. NEMA PB-2
- 2. UL Standard 891.

#### 1.04 SUBMITTALS – FOR REVIEW/APPROVAL

- A. The Equipment Supplier shall provide a factory shop drawing review for up to three (3) Owner's Representatives. All costs, including transportation, lodging and meals, for this review shall be borne by the Equipment Supplier.

- B. The following information shall be available at the factory review:

- 1. Master drawing index
- 2. Front view elevation
- 3. Floor plan
- 4. Top view
- 5. Single line
- 6. Schematic diagram
- 7. Nameplate schedule
- 8. Component list
- 9. Conduit entry/exit locations
- 10. Assembly ratings including:
  - a. Short-circuit rating
  - b. Voltage
  - c. Continuous current
- 11. Major component ratings including:
  - a. Voltage
  - b. Continuous current
  - c. Interrupting ratings

12. Cable terminal sizes

13. Product data sheets.

C. Where applicable, the following additional information shall be submitted to the Engineer:

1. Busway connection
2. Connection details between close-coupled assemblies
3. Composite floor plan of close-coupled assemblies
4. Key interlock scheme drawing and sequence of operations.

#### 1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in paragraph 1.04
2. Wiring diagrams
3. Certified production test reports
4. Installation information
5. Seismic certification and equipment anchorage details.

B. The final (as-built) drawings shall include the same drawings as the original construction drawings and shall incorporate all changes made during the manufacturing process.

#### 1.06 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the circuit protective devices within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g's (3.2-11 Hz), and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

E. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

#### 1.07 REGULATORY REQUIREMENTS

- A. The low-voltage switchboard shall be UL labeled.

#### 1.08 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

#### 1.09 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

### PART 2 – PRODUCTS

#### 2.01 MANUFACTURERS

- A. Cutler-Hammer
- B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

#### 2.02 RATINGS

- A. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current 65,000 amperes symmetrical at rated voltage.
- B. Voltage rating to be as indicated on the drawings.

#### 2.03 CONSTRUCTION

- A. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.
- B. All sections of the switchboard shall be front and rear aligned with depth as shown on drawings. All protective devices shall be group mounted. Devices shall be front removable and load connections front and rear accessible. Rear access shall be provided.
- C. The assembly shall be provided with adequate lifting means.
- D. The switchboard shall be Cutler-Hammer type Pow-R-Line C utilizing the components herein specified and as shown on the drawings.

- E. The switchboard shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

#### 2.04 BUS

- A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on minimum 1000A per square inch of bus density
- B. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.
- C. A copper ground bus (minimum 1/4 x 2 inch), shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
- D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

#### 2.05 WIRING/TERMINATIONS

- A. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
- B. Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size as indicated on the drawings.
- C. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.
- D. All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

#### 2.06 POWER CIRCUIT BREAKERS MAIN AND TIE

- A. Protective devices shall be drawout low-voltage power air-circuit breakers, Cutler-Hammer type DSII or approved equal. Frame ratings shall be 800, 1600, 2000, 3200, 4000, or 5000 amperes. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
- B. Breakers shall be electrically operated (EO) as indicated on the drawings.
- C. Electrically operated breakers shall be complete with 120V AC operators, control switch, plus red and green LED indicating lights to indicate breaker contact position. AC source shall be taken from a control power transformer internal to the switchgear assembly.
- D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65,000 amperes. To assure a fully selective system, all circuit breakers shall have 30-cycle short-

- time withstand ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.
- E. Where circuit breakers are equipped with current limiters, the combination shall have short-time ratings in accordance with the characteristics of the limiter selected.
  - F. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.
  - G. Main and Tie power circuit breakers shall be provided with trip units.
  - H. For drawout applications the breaker cell shall be equipped with drawout rails and primary and secondary disconnecting contacts. The stationary part of the primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts suitably spaced shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs.
    - 1. The secondary disconnecting devices shall consist of floating fingers mounted on the removable unit and engaging flat contact segments at the rear of the compartment. The secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in the "connected" and "test" positions.
    - 2. The removable power circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for drawout application. It shall have four (4) positions: CONNECTED, TEST, DISCONNECTED, and REMOVED all of which permit closing the compartment door. The breaker drawout element shall contain a worm gear levering "in" and "out" mechanism with removable lever crank. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering "in" or "out" of the cell. The breaker shall include a provision for padlocking open to prevent manual or electric closing. The padlocking shall also secure the breaker in the connected, test or disconnected position by preventing levering.

## 2.07 TRIP UNITS

- A. Digitrip RMS 910

## 2.08 MOLDED CASE CIRCUIT BREAKERS – 1200A AND BELOW

- A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics and shall be Cutler-Hammer type Series C or approved equal.
- B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
- C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

- D. Circuit breakers 800 ampere frame and below shall be Cutler-Hammer type Series C with thermal-magnetic trip units and inverse time-current characteristics.
- E. Ground fault protection shall be provided where indicated.
- F. Where indicated provide UL listed circuit breakers for applications at 100% of their continuous ampere rating in their intended enclosure.

#### 2.09 MISCELLANEOUS DEVICES

- A. Key interlocks shall be provided as indicated on the drawings.
- B. Control power transformers with primary and secondary protection shall be provided, as indicated on the drawings, or as required for proper operation of the equipment. Control power transformers shall have adequate capacity to supply power to the transformer cooling fans.

#### 2.10 CUSTOMER METERING

- A. Microprocessor-Based Metering System
  - 1. PXM-2000 Series
- B. Current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.
- C. Fused potential taps as the potential source for metering as shown on the drawings.
- D. Ethernet/Web/BACNET IP communications.

#### 2.11 ENCLOSURES

- A. NEMA 1 Enclosure

#### 2.12 NAMEPLATES

- A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16-inch high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.
- B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

#### 2.13 FINISH

- A. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchboard shall be ANSI 61 light gray.

#### 2.14 TRANSIENT VOLTAGE SURGE SUPPRESSION

- A. Provide transient voltage surge suppression.

### PART 3 – EXECUTION

### 3.01 FACTORY TESTING

- A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
  - 1. The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 volts for one (1) minute between live parts and ground, and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 volts for one (1) minute between live parts and ground.
- B. The manufacturer shall provide three (3) certified copies of factory test reports.

### 3.02 MANUFACTURER'S CERTIFICATION

- A. A certified test report of all standard production tests shall be available to the Engineer upon request.

### 3.03 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's instructions, contract drawings and National Electrical Code.
- B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to either Contractor supplied floor sills or the floor level to 1/8 inch per 3-foot distance in any direction. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

### 3.04 FIELD ADJUSTMENTS

- A. A Manufacturer's Service Representative shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.
- B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with an approved short circuit and protective device coordination study shall be carried out by the Manufacturer's Service Representative at no additional cost to the Owner.
- C. Assist temperature controls contractor with BACNET IP connection to meter for monitoring energy usage.

END OF SECTION 262413

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1. Final as-built drawings and information for items listed in section 1.04.

#### 1.06 QUALIFICATIONS

- A. For the specified herein, the manufacturer shall be ISO 9000 certified.
- B. The manufacturer must have a 24-hour response capability with nationwide field engineering personnel. The field service organization must have fully accredited, power system Engineers located across the North America who are capable of performing complete grounding, Power Quality analysis, and coordination studies. Factory trained TVSS sales personnel do not qualify as Power System Engineers.
- C. The manufacturer of the transient voltage surge suppression equipment shall be the same manufacturer as the manufacturer of the low voltage distribution equipment in which the TVSS units are installed.
- D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of Uniform Building Code (UBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, UBC: a peak of 2.15g's (3.2-11 Hz), and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.
- E. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
  1. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.
  2. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
  3. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

#### 1.07 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of manufacturer's instructions shall be included with the equipment at time of shipment.

#### 1.08 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.

## PART 1 – GENERAL

### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General, Supplementary, and Special Conditions apply to all lighting installations.
- B. Section 260500 Common Work Results Electrical
- C. Section 260533 Raceway and Boxes
- D. Section 260529 Low Voltage Wiring
- E. Section 260923 Lighting Controls

### 1.02 REQUIREMENTS OF WORK

- A. The Basic Electrical Requirements apply to all electrical materials, equipment, installations and services supplied under Dimmer package.
- B. The Electrical Contractor shall obtain a Bill of Materials from the Lighting Supplier(s) listed herein or proposed for substitution. The Bill of Materials shall be submitted with the Contractor's bid and shall include, but not limited to, the following:
  - 1. All lighting fixtures
  - 2. All fixture accessories
  - 3. Number, fixture type and lamp type to be provided
- C. The Electrical Sub-Contractor and the Lighting Supplier(s) are responsible for the installation of a complete and operating lighting system in accordance with the intent of the Contract Documents.

### 1.03 SUBMITTALS

- A. The following items shall be submitted for approval prior to ordering.
  - 1. Lighting Fixtures
- B. All submittals shall be submitted electronically in PDF format

### 1.04 INSTALLER QUALIFICATIONS

- A. A firm with at least five (5) years of successful installation experience on projects with electrical works similar to this project.

## PART 2 – PRODUCTS

### 2.01 LIGHTING FIXTURE MANUFACTURERS

- A. Acceptable Manufacturers
  - 1. FineLite
- B. All others must submit for approval.

### 2.02 FIXTURE SCHEDULE

- A. FINELITE CAT# HPR LED-A-2X4-DCO-HO-120-SC-C1 No substitutions ISU Standard

## PART 3 – EXECUTION

### 3.01 GENERAL

- A. All equipment shall be installed in a workmanlike manner and shall conform to industry Standards for this type on installation.
- B. All fixtures shall be plumb and square with ceilings and walls
- C. Support for fixtures in or on a grid type ceiling. Use grid for support.
  - 1. Install grid support wires on all four corners of each fixture.
  - 2. Install support wires or support chains, minimum of two, independent of the ceiling grid to each fixture not more than 6 inches from the corner on diagonally opposite corners of each fixture.
- D. Flange mounted fixture installation shall be per Manufacturer's instruction.

### 3.02 TESTING

- A. "Megger" all wiring prior to energizing.
- B. Test all switches and sensors for proper operation
- C. Verify proper operation of each fixture.
- D. Test each emergency fixture by interrupting the power to the fixture.

### 3.03 CLOSEOUT

- A. Prior to final acceptance and Project closeout the Contractor shall:
  - 1. Clean all fixtures and lenses inside and outside
  - 2. Replace any burned out lamps

### 3.04 WARRANTY

- A. As Specified on each individual fixture listed herein.
- B. In lieu of a specific fixture warranty, all parts and labor on this Project shall be warranted for a period of one (1) year after start-up and Owner acceptance.

END OF SECTION 265100

## SECTION 26 55 61 – THEATRICAL LIGHTING AND CONTROLS

### PART 1. GENERAL

#### 1.01 GENERAL CONDITIONS

- A. Refer to Bid forms, Division 1 General Conditions and Division 265561. It is called to the Electrical Contractor's attention that the work of this section includes all requirements listed therein.
- B. The systems: complete functioning apparatus consistent with the current state of the art of theatrical practice and including all components necessary for the operational functions specified, whether or not each separate device is specifically mentioned.
- C. Furnish all required control wiring. All components necessary to make the system a working Network shall be included in the bid. Actual length of network cabling and system layout shall be refined during the project submittal process.
- D. Attention is called to the requirement to protect control electronics and dimmer outputs from momentary voltage changes that may be caused by clock systems.
- E. Products utilized in the bid must conform to the functionality, quantity, and quality of all requirements of the design-basis specifications and drawings including the contract documents.
- F. The services of systems integration firm's responsibilities are specified herein.
- G. The Theatrical Lighting Systems Integrator shall coordinate the installation of complete Specialty Lighting Systems and other equipment as described herein and shown on the Theatrical drawings
- H. The Electrical Contractor and the Theatrical Lighting Systems Integrator shall refer to this specification and the drawings to confirm each entity's exact scope of work. Inform the Electrical Engineer and the ISU Technical staff prior to the completion of scope clarification of any conflicts or unresolved scope issues in order that they may determine appropriate responsibilities and document this decision.
- I. Equipment manufacturers authorized system integrator shall test installed system, instruct Owner's designated personnel in operation of the system, and assist the ISU Theater staff and Electrical Engineer in Programming the network and theatrical lighting controls.

#### 1.02 CLASSES OF MATERIALS AND INSTALLATIONS SPECIALTY LIGHTING, DIMMING, CONTROL SYSTEM

- A. Provide all labor, materials, and equipment for the complete installation of specialty lighting, dimming and control systems as shown on the drawings and specified herein.
- B. Refer to drawings for dimensions and locations. Check and verify dimensions and details on drawings before proceeding with the Work. Report any discrepancy at once to Engineer. Should it appear the work intended to be described, or any of the matters relative thereto, are not sufficiently detailed or explained on the drawings or in the specifications, apply to the Engineer for further drawings for explanations, as may be necessary. Conform to these explanations in the work. If any question arises about the true meaning of the drawings or specifications, refer

the matter to the Electrical Engineer whose decision is final and conclusive. In no case submit a bid, or proceed on any work with uncertainty. The intention of this specification and the accompanying applicable drawings are to provide a job complete in every respect. Electrical Contractor is responsible for this result.

### 1.03 SUMMARY

- A. Provide labor, materials and equipment necessary for the complete installation of the theatrical lighting equipment and control systems.
- B. Base Bid work under this section includes, but is not limited to the following demolition & installation of the following components:
  - 1. Existing: Remove
    - a. Remove existing Strand Dimmer Rack, Dimmer Module & Control Modules.
    - b. Remove existing Theatrical Control Console & all associated accessories and store for reuse.
    - c. Remove all existing theatrical wiring devices and associated conduit and wiring.
  - 2. New: Provide and install complete
    - a. New dimmer racks with:
      - 1) ETC Sensor Dimmer Rack
      - 2) Thru-power modules which can operate as relays and dimmers as required
      - 3) CEM3 Control module with QR attributes.
    - b. New Centralized Architectural Control & Network Control Rack
      - 1) Architectural Processor
      - 2) Station Power Module
      - 3) 24 port patch and associated networking devices.
      - 4) DMX gateways
    - c. Architectural Control Stations
    - d. Theatrical Control Stations
    - e. Network Receptacles
    - f. DMX Receptacles
    - g. Emergency DMX control
    - h. New LED DMX 0-100% house lights
    - i. New Running Lights
    - j. New Safety Lights
    - k. New Stage Work Lights

### 1.04 INTENT

- A. It is the intent of the contract requirements to provide a complete specialty dimming, lighting control package as described herein including delivery and installation. The Electrical Contractor is responsible for complete Lighting Control system. The Theatrical Lighting Systems Integrator is responsible to coordinate with and assist the Electrical Contractor to properly execute the work of this section.
- B. These systems shall consist of the components and functions as described herein: shop drawings, as-built drawings, installation, and engineering supervision for checkout of installation, operation/maintenance manuals, and on-site operation instructions to local personnel. The systems shall be a complete functioning apparatus consistent with the current state of the practice of theatrical lighting including all components necessary for the operational

functions described whether or not each separate device is specifically mentioned. Provide and install any and all conduit and wire as required for a complete working system.

- C. Electrical Contractor and Theatrical Lighting Systems Integrator shall coordinate this work with all and other trades.

#### 1.05 COORDINATION

- A. Clearly indicate the work to be performed by other trade Contractors, and the materials which are adjacent or abutting the work of this Section. Coordinate as required, especially with concrete, drywall, ceiling and painting contractors to insure a finished and acceptable installation to the owner.
- B. Fixture plug-in locations as indicated on the electrical drawings are generalized and approximate, carefully verify locations with specifications, Electrical Engineer's plans, and other reference data prior to installation.
- C. Give ample notice of any special openings or rough-in required for placing equipment on the site in order to avoid cutting of completed work.
- D. Furnish the materials and labor for work included under this Section in ample time; and in sufficient quantities so that all of the work may be installed in proper sequence to avoid unnecessary cutting of walls.
- E. Coordinate and Schedule the work of this Section with the work of other Sections, utility companies and the telephone company so that there shall be no delay in the proper installation and completion of any part of each respective work. Construction work shall proceed in its natural sequence without unnecessary delay caused by the work of this section.
- F. Where work of this Section is to be flush or concealed, install it to assure that it does not project beyond the finished lines of ceilings or walls except as noted.
- G. Although the location of equipment included in the work of this Section may be shown on The Contract Drawings in a certain place. Actual construction may disclose that the location for the work does not make its position easily and quickly accessible. In such cases, call the Engineer's attention to this situation before installing this Work, and comply with his Installation instructions.
- H. Verify item conditions and furnish appropriate mounting details for each fixture. All mounting details shall be approved by Electrical Engineer and Theatrical Lighting Systems Integrator.

#### 1.06 QUALITY ASSURANCES

- A. A Theatrical Lighting Systems Integrator shall be included by each bidder with its team. Each Theatrical Lighting Systems Integrator will be required to demonstrate their understanding of the project scope, their capability to coordinate and execute their portion of the work, and their ability to respond to warranty and ongoing service calls as specified herein.
- B. Statement of Application: The Electrical Contractor, by commencing the work of this section assumes overall responsibility, as part of the warranty for the work, to assure that assemblies,

components and parts shown or required within the work of this section, comply with the Contract Documents.

1.07 STANDARDS

- A. All applicable requirements of Division 1, and all other sections of Division 26 govern all work in this Section. I
- B. NFPA 70 national Electrical Code 2012.
- C. All equipment provided for this project shall be UL listed where applicable standards have been established. Proof of UL listing shall be required prior to award of contracts.
- D. All Equipment: shall be the products of one manufacturer or supplier; complete with all required apparatus, devices, controls, lamps, accessories, etc., except as specifically noted herein. In the case of power control devices including emergency lighting equipment, dimmer racks, relay panels, power bays, and related components, these products must be the product of one manufacturer.
- E. System apparatus, conduit and wiring shown on drawings are for estimating purposes only. Actual work will depend on furnished product's manufacturer's standards. It is the Submitting Electrical Contractor's responsibility to ascertain the Manufacturer's requirements and shall be sized and located in conformity with minimum acceptable standards as Set forth in the Machinery's Handbook and all revisions to date.
- F. All moving parts shall have acceptable tolerances, mountings, connections, and accessories coordinated into the system in a manner approved by the Owner and Electrical Engineer. No wood construction or equipment shall be incorporated into the system excepting as may be set Forth in the specifications.
- G. All electrical and electronic parts and components: selected and installed shall be consistent with good practice and conservatively rated in their use in the circuit design. Each piece of equipment shall meet accepted basic engineering standards.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Dimming Systems and their component elements shall be delivered to this job site factory assembled and wired to the greatest extent practical, in strict accordance with the approved

shop drawings, samples, certificates, and shall be handled in a careful manner to avoid damage.

- B. Exposed finishes shall be protected during manufacture, transport, storage and handling. Materials that become damaged shall be repaired and/or replaced as directed at no cost to the owner.
- C. Equipment shall be stored under cover, above the ground, in clean, dry areas, and shall be tagged and/or marked as to type and location.
- D. Delivered equipment shall include wiring, sockets, ballasts, shielding, channels, lenses, lamps and other parts necessary for fixture installation of each fixture type.
- E. Contractor must schedule delivery of equipment to the site within the Contract approved schedule of installation.

#### 1.09 FIELD ENGINEERING SERVICES

- A. Manufacturer's Representative shall furnish engineering assistance as needed during delivery and installation to assist contractor. A qualified Field Engineer shall check the installation prior to initial energizing of the system. The field engineer shall supervise initial turn-on and shall make or cooperate with the installing contractor in making any required adjustments or trimming of components to enable the system to function as specified.
- B. The Field Engineer shall be factory certified and be fully experienced in the programming requirements of all the Electrical controllers.
- C. As a portion of the final inspection, the Factory Field Engineer will demonstrate the systems in the presence of the Owner and/or Electrical Engineer. He or she shall provide instructions in the use and maintenance of the system.
- D. The Theatrical Lighting Systems Integrator and the Field Engineer shall provide instruction in system operation and maintenance: a minimum two (2) hour period shall be provided for maintenance training. A minimum of two eight (8) hour period shall be provided for the lighting control system training. Training shall be offered at the Convenience of the Owner's schedule in the presence of the Electrical Engineer.

#### 1.10 INSPECTIONS

- A. The Electrical Contractor shall arrange for the Theatrical Lighting Systems Integrator to attend a minimum of two (2) coordination meetings during the construction.
  - 1. Pre-installation conference prior to the installation of major conduit rough-ins and dimmer rack placement.
  - 2. Post rough-in conference after conduit has been roughed in and dimmer racks have been installed but before major load and control wiring is pulled and/or dimmer rack terminations have begun.

- B. Attendance by the Theatrical Lighting Systems Integrator at any preliminary conference and or inspection shall not be construed as eliminating the possible rejection of various components during the final inspection.
- C. The final inspection shall be by the Electrical Engineer. Completion of all items and acceptance of the lighting control system as substantially complete shall be required prior to the instruction of the Owner's representatives/users.
- D. If inspection reveals any detail of construction, fabrication, or installation not in strict accord with the specification or the contract requirements; approval and payment will be withheld in accordance with the General Conditions. The cost for additional inspections required for the approval of the Theatrical Lighting System shall be borne by parties show to be responsible for failure to comply with Plans, Specifications and Bid Documents.

#### 1.11 TESTING

- A. Standard factory testing by the manufacturer shall be performed and typewritten copies submitted to the Owner for record purposes.
- B. The manufacturer shall provide for final adjustments for systems. These adjustments shall accomplish at least the following:
  - 1. Provide smooth, continuous light level control from zero percent light output through full light output for both increasing and decreasing light levels.
  - 2. Limit dimmer output voltage to all incandescent circuits to between 90 and 95 percent of the rated lamp voltage or as directed by the owner.
  - 3. Eliminate all radio frequency interference.
- C. During testing and adjustment of the systems it will be necessary to rearrange portable fixtures from circuit to circuit in order to test each dimmer for compliance with operating requirements. The Electrical Contractor shall provide labor for testing as directed.
- D. The manufacturer shall provide labor to assist the Electrical Engineer with field configuration of system software during final adjustments and inspection of installation.

#### 1.12 SPECIALTY LIGHTING CLOSEOUT SERVICES

- A. The Theatrical Lighting Systems Integrator shall provide an allowance for initial programming with the school staff.
- B. The Theatrical Lighting Systems Integrator shall provide an allowance of eight (8) hours minimum for initial programming of the Architectural system with the school staff in addition to the manufacturers turn-on and programming time.
- C. The cost of programming, focus, and instruction shall be part of The Theatrical Lighting Systems Integrator 's price to the Electrical Contractor for this project.

#### 1.13 UNDERWRITERS LABORATORIES

- A. All equipment and components shall be approved and Listed by UL where applicable standards have been established. This approval applies specifically but is not limited to Dimmer Racks, Dimmer Modules, Breaker Panels and Wiring Devices.
- B. All equipment: manufactured and tested in accordance with the applicable portions of the latest editions of UL, ETL, NEMA, ASA, AIEE
- C. USITT, ESTA, PASA, and IPECA standards.

#### 1.14 PAINTING

- A. All consoles, racks, panels, and other metal parts are to be provided with the manufacturer's standard powder coat over an approved primer, except as specified otherwise.

#### 1.15 ACCESSORIES

- A. All loose accessories shall be delivered to the owner and installed or stored as directed.

#### 1.16 WARRANTY

- A. All systems, including all parts and labor, shall be under warranty for a period of not less than two (2) years from the date of written final acceptance. Manufacturers of products provided by 26 55 61 must provide standard warranties which run directly to the Owner. Manufacturers standard warranties provided under this section must allow for repair or replacement of defects in materials or workmanship under the warranty period. In the event that any of the equipment should fail to produce capacities or meet design characteristics as specified, it shall be replaced with equipment that will meet requirements without additional cost. After occupancy, any necessary work performed shall be done at the convenience of the Owner's operational schedule, including overtime, if required. Acceptable Manufacturer's Standard Warranties on power control, architectural control, and emergency power and control equipment shall not disclaim or attempt to disclaim implied warranties available under Title 26, Article 1 of the Indiana Code. Bids which do not comply or which include products which do not comply with this section shall be construed as unresponsive and rejected by Owner. Warranties and other terms and conditions provided by manufacturers must conform with all other sections of the specifications including Section 00 21 13, 1.14.

#### 1.17 MAINTENANCE SERVICES

- A. The Theatrical Lighting Systems Integrator shall maintain a theatrical lighting control systems service center with a minimum of one (1) factory-trained full-time factory trained and authorized service technician. The service center shall be located within 125 miles of Indianapolis, IN. The service center and the named technician shall have been authorized in writing by the Specialty Dimming Systems Manufacturer to perform all necessary maintenance, repairs and upgrades to both the equipment and its embedded accessible software. Provide proof of factory authorization prior to award of contract for this project. In addition, the Manufacturer shall maintain a 24-hour service hotline and shall provide certification of its existence.
- B. The Theatrical Lighting Systems Integrator, as part of the system requirements, shall provide equipment and services necessary to passively monitor all connected network and RDM equipment and devices. This monitoring shall include the use of syslog, UDP messages, eDMX protocols, sACN, ArtNet, or similar, RDM messages or sensor data from RDM devices. Such equipment and/or services shall send email and SMS alerts to Owner and the local Factory trained technician from a secure, centralized cloud-based system. Owner shall be contacted within 12 hours of a system error or failure by a factory trained technician. Duration of this

service shall be provided for no less than three (3) years after the date of system commissioning and owner acceptance. Additional monitoring shall be available for purchase on a yearly basis.

#### 1.18 SUBMITTALS

- A. Manufacturer shall provide seven (7) sets of full system submittals. Submittals shall include:
  - 1. Full system riser diagrams illustrating interconnection of system components, wiring requirements, back box sizes and any special installation considerations.
  - 2. Full set of printed technical data sheets.
  - 3. Detailed set of dimmer schedules.
  - 4. Detailed set of circuit and control schedules, including a complete list of all deviations from specifications.
  - 5. A complete Bill of Materials listing all equipment including Manufacture, Model Number and Capacities.
  - 6. The Bill of Materials shall also include a detailed list of all associated accessories and services to be provided per the published plans and specifications.
  - 7. The Bill of Materials shall also include complete detailed set of circuit and control schedules, including a complete list of all deviations from specifications.
- B. Manufacturer shall provide any additional information, including equipment demonstrations, as required by the engineer and owner to verify compliance with specifications prior to the award of this project.

#### 1.19 ACCEPTABLE MANUFACTURERS

- A. Electronic Theatre Controls is the basis of design and shall be included in the Electrical Contractor bid. This Manufacture shall be one who has been continuously engaged in the manufacture of lighting control equipment for a minimum of ten years. All dimmer and cabinet fabrication must take place in a U.S. manufacturing plant.
- B. All equipment shall be built to the standards of Underwriters Laboratories, Inc., the National Electric Code and the United States Institute for Theater Technology. Permanently installed power distribution equipment such as dimmer racks and distribution shall be UL Listed, and bear the appropriate labels
- C. Other than as specified above, manufacturers are generally acceptable so long as the products utilized are of like quality and quantity and meet or exceed all physical, electrical, and functional requirements contained within the specifications and drawings. All bidders must provide a complete working system which meets the functional, contractual, and performance requirements of these specifications. It is the responsibility of the Electrical Contractor to verify that all products conform to this requirement. Products which are determined by the Owner to be non-conforming to the specifications shall be grounds for rendering a bid unresponsive. If there is any doubt about a product's acceptability, the Electrical Contractor should contact the theatre consultant no later than ten (10) days prior to the bid date.

#### 1.20 ACCEPTABLE SYSTEM INTEGRATORS

- A. Approved Theatrical Lighting Systems Integrator shall be ones that maintain full time factory approved field service technicians:
- B. Indianapolis Stage, Indianapolis IN  
Scenic Solutions, Dayton OH  
Vincent Lighting Systems, Erlanger KY

PART 2. PRODUCTS

2.01 LIGHTING SYSTEM AND ACCESSORIES

A. General

1. The lighting control desk shall be a microprocessor-based system specifically designed to provide complete control of stage, studio, and entertainment lighting systems. The device shall be the Gio as manufactured by Electronic Theatre Controls, Inc., or equal.
2. The system shall provide control either 4,096 or 24,576 outputs on a maximum of 32,768 control channels, patched across any number up to 99,999. Systems that require external co-processing to control 24,576 outputs shall not be acceptable. Output shall be distributed over a 10/100 MB Ethernet network using Net3/ACN, ETCNet 2, Avab and/or ArtNet (multi-cast) protocols. The user shall be able to control the application of protocols at an individual address level.
3. The system shall support full bi-directional RDM communication with compatible devices via Net3 DMX/RDM Gateways. RDM communication shall adhere to ANSI standard E1.20-2006 Entertainment Technology – RDM – Remote Device Management over DMX512 Networks. Supported RDM features shall include:
  - a. Discovery and Identification of RDM capable devices
  - b. Setting of start addresses, operating modes and additional settings as exposed by connected devices and controllable via RDM
  - c. Viewing of Sensor data as provided by connected devices
  - d. Error reporting as provided by connected devices
4. A maximum of 10,000 cues, 999 cue lists, 1000 groups, 1000 presets, 4 x 1000 palettes (Intensity, Focus, Color and Beam), 99,999 macros, 1000 effects, 1000 curves, 1000 color paths and 1000 snapshots may be contained in non-volatile electronic memory and stored to an onboard solid-state hard drive or to any USB storage device.
5. Recorded cue lists may be played back simultaneously on a maximum of 200 faders. Channels shall, by default, respond to cue information by last instruction, with discrete rate control provided for all cues. The console may be placed in Tracking or Cue Only mode by the user as a system default and overridden on individual record actions as required. HTP/LTP intensity flags, assert, proportional, intensity master or manual master fade control and priority status may be placed on each cue list. It shall also be possible for a cue list to contribute to playback background states or to withhold such contributions.
6. A Master Playback fader pair shall be provided. The 100 mm motorized fader pair may execute move fades, state fades or all fades, with IFCB cue level timing,
7. Ten 100mm motorized faders shall be user configurable across 100 pages and provide additional playback faders (up to 200), additive, inhibitive or effect submasters (up to 999), and one grand master. Presets and IFCB palettes may be loaded to faders for playback control, either individually or in user-defined lists. Virtual fader control is also provided.

8. The system shall have two 12.1 inch integral articulating multi-touch displays. Content posted to these displays shall be user definable. Displays shall support multiple interpreted simultaneous touches.
9. A high-resolution level wheel shall be provided to control intensity for selected channels and scrolling/zooming of selected displays. Four page-able high-resolution encoders shall be provided for control of non-intensity parameters. Non-intensity encoders may be operated in coarse or fine mode, with the amount of movement per revolution of the encoders in coarse mode definable by the user. Tactile feedback for full frame (color or image) operations shall be provided. The expand function for frame table devices shall provide a graphic representation of all images and colors in the associated device for instant selection. The display shall also provide an indication of the current value for the associated parameter, based on channel selection. A high-resolution rate wheel, which may also be used for fader paging, is provided.
10. Control surface buttons shall be backlit. The backlighting shall provide indication of functional states. Backlight intensity shall be user configurable and shall automatically dim after a defined period of inactivity.
11. Control and programming features for automated fixtures shall also include: a standard library of fixture profiles, the ability to copy and edit existing profiles and create new profiles, patch displays including channel and output addressing, 16-bit fade resolution, color characterization allowing color mixing and matching to color media data.
12. System information, including playback status, live output and blind values for all record targets shall be displayed on a maximum of three external high resolution Display Port monitors, which may also be multi/touch-screens. All displays may also be routed to the two integral touch screens.
13. A context sensitive on-line Help feature shall explain and provide an example of the operation of each feature of the system. The help system shall be integrated into the on-board user manual via hyperlinks.
14. A fully integrated Virtual Media Server feature shall allow the user to map images and animations to a rig array. 40 such maps may be created, each with 12 layers. Systems that rely on external hardware or software for this functionality shall not be acceptable.
15. User-definable, interactive displays may be created. These displays, which can be used in live and blind operating modes, allow graphical layout of channels, desk buttons and programming tools. Standard symbols are provided, and the user may import their own symbols or graphics. Each symbol may be individually defined with data feedback characteristics. Non-interactive status information, such as a mirror of other user's command lines, may also be included in the display. A graphical browser is provided for fast selection of these views. Multiple zoom factors and placements may be stored and recalled for each display
16. A full-function external backlit alphanumeric keyboard shall be provided. The keyboard shall allow labeling of all show content. The central touch screen shall also repaint to access a virtual alphanumeric keyboard.

17. Software upgrades shall be made by the user via USB flash drive. It shall be possible to install software updates in all desks, processor units and remotes from one device over the network.
18. The operating software shall be loaded into program execution memory from the internal solid-state hard drive when the console is powered. In the event of an uncontrolled shutdown, the device shall return to its last output state when power is restored. Devices requiring a UPS to provide such protections shall not be acceptable.
19. Dimmer monitoring and configuration features shall be provided (in conjunction with ETC's Sensor+, Sensor 3 or FDX dimming systems) to allow indication of dimming system status, dimmer load monitoring and show specific configurations. Communications with the dimming system shall utilize ANSI E1.17 2006 - Entertainment Technology - Architecture for Control Networks.
20. Show data may be created and modified on a personal computer, using either Windows 7 or higher operating systems, with a free offline editing application. The offline editor may also run natively on Intel-based Macintosh platforms using OS 10.11 (El Capitan) or later. The program shall also allow output to visualization software supporting the same protocols as the lighting system.
21. PC using Windows 7 or higher or an Intel-based Macintosh computer using OS 10.11 or later running a client software application shall be able to connect to a control system via the network and view or modify current show data in an independent display environment, using an ETCnomad key. When connected without the key, the computer shall operate in Mirror Mode, with the device to be mirrored selectable by the user. Systems that do not provide client software that may run natively on the Apple platform in this environment shall not be acceptable.
22. Synchronized backup shall be provided via another full desk on the network, a remote processor unit or a PC/Mac using ETCnomad. The backup unit shall maintain synchronized playback with the master and shall take over control of the lighting system upon loss of communication with the master, either automatically or upon user confirmation. Use of two RPU's to service and backup system output is also supported.
23. A maximum of 99 users may access and interact with show data simultaneously. Each user shall have an individual workspace. User identification may be assigned to more than one control device, allowing users to work in tandem, or allowing a designer/ALD to mirror the current display format, mode and command line of the associated programmer. Partitioned control allows discrete control of channel/parameter groupings by user. Partitioned control may be easily enabled and disabled with no need to merge show data from multiple users.
24. Show files are saved across the system to all available integral hard drives simultaneously.
25. The system shall support up to 32 individual simultaneous Time Code inputs or Event lists using Show Control Gateways.
26. Systems that do not provide the above capabilities shall not be acceptable.

B. Controls and Playback

1. Manual Control and Programming Section

- a. The programming keyboard shall be grouped by function. Major groupings shall be record target functions, numeric keys, level assignment functions, display navigation functions and controls, as well as non-intensity parameter controls.
- b. The command keypad shall be fully interactive with direct select controls, Magic Sheets and in-cell editing.
- c. Non-intensity parameters may be set numerically via an extensible keypad on the central LCD. This control shall be fully interactive with the page-able encoders. The LCD touch screen associated with the encoders shall display the current encoder function. The touch screen shall also access available modes for each parameter type, min and max values for each parameter as applicable, as well as home position on a parameter basis. Each encoder shall support shift functions for fine control. The range of motion of coarse control may be set by the user. Tactile encoder feedback shall indicate full and half frame positioning of certain controls.
- d. Only those parameters available for control in the active lighting system shall be displayed for control. Displays shall lowlight parameters not available to selected channels. Alternatively, the encoders may be placed in a state allowing parameters not applicable to the current selection to be suppressed.
- e. Lamp controls provide direct access to luminaire functions such as striking and dousing arc lamps and calibrating entire fixtures or individual mechanisms of fixtures, as provided by the luminaire manufacturer. User access to these features is normalized across all manufacturers for ease of use. Use of a "control channel" for accessing these functions shall not be required and systems requiring use of control channels for these functions shall not be acceptable.
- f. Fan functions shall be provided both via command line operation and through encoder controls.
- g. Highlight shall be supported, with user definable highlight values. Lowlight conditions may be defined for selected, but not specified channels. Rem Dim commands, at specific levels by channel, may be optionally and automatically called with the highlight command.
- h. Fixtures with color mixing may be set with direct additive or subtractive encoder controls or the command line, as well as via the color pickers. Six optional color spaces are supported, as well as tinting tools, and spectrum tools for systems with more than three color mixing elements. Color may also be set directly to a gel match via a graphic selection tool or from the command line. The gel picker shall support tools for identifying similar colors, show favorites and graphic indications of gel locations. Color Path tools, allow the user to control the live fade of fixtures through the color space, with intensity dampening.

- i. The Virtual Media Server function shall allow the user to create layouts of devices, identified as pixel maps. Media content (images, movies, text and procedurally generated effects) may then be applied, manipulated and stored. Stock content is provided and the user may import custom imagery and animations.
- j. Macros may be set to run as default. Default macros called manually shall post to the command line, but executed via cue lists shall run in the background. The user may override this behavior by defining the macro to always execute in the foreground or background, regardless of the recall method. Startup, Shutdown and Disconnect macros may also be defined.

2. Playback Section

- a. The playback faders shall consist of a motorized 100mm Master Fader pair with associated Load, Go and Stop/Back buttons and a 10 x 100 page fader array.
- b. Up to 200 playback faders may be defined on the 10 fader x 100 page fader array. Each playback shall have an associated 100mm motorized potentiometer and three control buttons.
- c. Faders may be grouped for playback with slides and button action defined by the user.
- d. It shall be possible to instantaneously halt an active cue, back to the previous cue, manually override the intensity fade or manually override the entire fade.
- e. It shall be possible for a cue list to contribute to the background state or for the contents of each cue list to be withheld from such. Priority and background priority states may be established.
- f. Playback faders shall have the following associated controls:
  - 1) Freeze, which halts the output of the fader
  - 2) Stop Effect, which stops the action of an effect
  - 3) Filter, to assign filter states to a fader
  - 4) Go To Cue 0, to reset a cue list
  - 5) Off, to turn off the contents of a playback, releasing control to the background state or to set to null.
  - 6) Assert, to replay an active cue
  - 7) Release, to release control to the background and reset the cue list.
  - 8) Timing Disable, channel filters and independent status may also be defined.
  - 9) The potentiometer shall be configurable as a proportional master, an intensity master, or manual master. Support for rate, effect rate, effect size and Master Only controls is also provided. Filtered manual timing masters and effects masters may be configured.
  - 10) Rate override and fader paging are supported with a wheel encoder and associated controls.

3. Submasters

- a. Up to 999 proportional, fully overlapping additive, effect or inhibitive submasters may be defined. Submasters shall have colored LEDs to indicate submaster status. Each submaster may have fade up, dwell and down fade times. Each has a bump and assert/channel select button.
    - b. Submasters may be set to HTP or LTP intensity. Non-intensity parameters on submasters shall be LPT only.
    - c. Exclusive mode for a submaster shall prohibit the live contribution of that submaster from storing to cues or other submasters. Shield mode prohibits access of associated channels from any other playback or manual control operations.
    - d. A submaster potentiometer may be defined as proportional or intensity master. When set as intensity master, a mark and unmark feature is supplied. Priority states may be assigned.
    - e. Motorized faders shall set submasters to required positions as fader pages are changed.
    - f. The submaster blind buffer shall be linked directly to live playback.
    - g. It shall be possible to set submaster values directly from the command line.
    - h. LTP submasters may be set to fade to background or to minimum value when the fader is returned toward zero.
    - i. Submaster values may contribute to the background state or withheld from such.
  - 4. Grand Master Fader
    - a. The location of the Grand Master shall be user definable. The grand master shall have associated blackout and blackout enable buttons.
    - b. Blackout shall send all associated intensity outputs to zero. Non-intensity outputs shall not be affected.
    - c. Motorized faders shall set grand masters to required positions as fader pages are changed.
- C. Display Controls
- 1. Format shall change the view of selected displays.
  - 2. It shall be possible for the user to choose which parameter categories or parameters (s)he wishes to display.
  - 3. Flexichannel modes shall change which channels are viewed in selected displays, as follows:
    - a. No modes
    - b. Masters only/ cells only
    - c. Use Partitions
  - 4. Flexichannel states shall change which channels are viewed in selected displays, as follows:
    - a. All channels

- b. Patched channels
  - c. Show channels
  - d. Active/Moved channels
  - e. Selected channels
  - f. Manual Channels
  - g. View channels (user identified list)
  - h. Channels with discrete timing
- 5. Expand shall extend the selected view sequentially across connected displays.
  - 6. [Time] depressed shall display discrete timing data. [Data] suppressed shall display absolute values of referenced data. These controls may be latched.
  - 7. Displays may also be toggled to show stored data currently manually overridden, the source of the current parameter data, output level, patch assignment, part structure and referenced marking data.
  - 8. User definable magic sheets shall provide alternative display of and access to channels and record targets. Multiple magic sheets may be created, each with a variety of zoom and placement factors for rapid recall of the required view.
  - 9. Playback status displays are provided with a variety of different formats. Indications are provided per cue for live moves (lights fading from zero and also moving non-intensity parameters) and dark moves (inactive lights which have stored non-intensity parameter moves). The user may select a static or dynamic time display in the cue list itself.
  - 10. Display content including which of the workspaces is in focus on any of the five monitors and what views are docked in those workspaces may be instantly recalled using snapshots.

D. Operating Modes

- 1. Live Mode
  - a. Channel lists may be constructed using the +, -, and Thru keys as well as the direct selects. Channel selection is fully interactive, regardless of the method used.
  - b. Levels may also be set with the keypad, level wheel and non-intensity encoders. "Selected" channels shall be those last addressed and under keypad control. Controls are provided for single button access to the last selected channel list, all channels with manual levels and all active channels.
  - c. Channels may be set at a user defined default level using the Level key. +% and -% keys adjust channels quickly by user definable values.
  - d. Channels and/or channel parameters may be captured. Capture mode shall allow the user to selectively capture channel data at specific levels. Captured data shall be indicated on the Live display.

- e. Sneak shall be used to restore specified channels to background states, default values, or to send them to specified values, in user specified times.
- f. Selected channels may be set at a level or held to current values while all other channels are set to zero using Rem Dim. Toggling Rem Dim shall restore all unselected channels to original levels. The Rem Dim level shall be user definable via the command line or with a default setup value.
- g. Channels may be recorded into groups for fast recall of commonly used channels. 1000 groups shall be available. Groups shall store selection order and subgrouping functions. The Offset function supports rapid creation of ordered groups, including reverse and random order.
- h. Parameter settings may be stored to Intensity, Focus, Color and Beam Palettes and to Presets. All referenced data may be stored to whole numbers or to up to 99 decimal places between each whole number.
- i. The following conditions may be placed on a channel or channel parameter to be included with a cue record action.
  - 1) Discrete fade time and/or delay
  - 2) Block flag
  - 3) Assert flag
  - 4) IFCB Filters, which may be set at a parameter level.
  - 5) Release and Restore
- j. 999 cue lists may be stored. Cues may be recorded in any order. Up to 99 decimal cues may be inserted between any two whole number cues. Each cue may contain a maximum of twenty parts.
- k. It shall be possible to record cues and cue parts with the following information:
  - 1) Any collection of channel data, as determined by the use of "Record", "Record Only" or selective store commands, combined with parameter filters.
  - 2) Cue Level timing and delays for Intensity Up, Intensity Down, Focus, Color and Beam.
  - 3) Follow or hang time
  - 4) Link instruction
  - 5) Loop value
  - 6) Block, Assert, Preheat, and/or Mark Flag
  - 7) Curve
  - 8) Alfade
  - 9) Label and note
  - 10) Execute list to trigger other activity (execute cue lists, cues, macros and snapshots). Cue list partitions shall be available to curate list content.

- l. Non-intensity channel parameters may be marked (preset), in two ways. Automark presets any parameters transitions in the cue just prior to intensity becoming active. Automark may be disabled on a cue or cue part basis, enabling a "live" move. Alternatively, non-intensity parameters may be marked to a specific cue with a single command instruction. It shall not be necessary to store these parameters directly into the cue in which the movement is to occur.
  - m. Any channel parameter may be stored with an effect instruction. These effects may contain relative offsets from current value, or absolute instructions. Effects may be progressive action or on/off states. Entry and exit behaviors shall modify the channel parameters activity when beginning and ending the effect.
  - n. Update may be used to selectively add modified parameter data quickly to that parameter's current source. Trace may be used to modify the data to the original source of its move instruction. It shall be possible to update inactive record targets. A context sensitive display provides detailed information regarding the results of the update command.
  - o. Recall From quickly pulls specified data from record targets or other channels into the current view. Recall on an HTP basis shall be provided.
  - p. Copy To quickly copies selected data to specified channels or other record targets.
  - q. Address and channel check functions shall be provided.
  - r. Channel parameters may be "parked" at levels. Those levels are not added to any live record operations, nor may they be changed until the parked element is "unparked". Scaled park provides real time proportional adjustment of stored intensity values. Address Park shall also be provided.
  - s. About shall provide detailed status of selected channels or specified record targets. This shall include current source, current value, discrete timing, parked value, marked to and for indications. Background levels and current DMX output are also displayed. Channel usage indicates submaster and cue information and also provides a "dark moves" report on a per channel basis.
  - t. 1000 snapshots may be stored which instantly recall specified front panel and display configurations.
  - u. Live data may be displayed in a summary view, a detailed table orientation or a user-defined magic sheet.
  - v. Query shall allow selection of channels by their current or possible state. Keywords and fixture types shall allow quick access to fixtures.
  - w. User definable home positions may be defined on a per- channel/per-parameter basis.
  - x. Undo shall be used to sequentially step back through manual operations or to undo record and delete actions. It shall be possible to undo multiple commands in one action.
- 2. Blind Mode
  - a. The Blind display allows viewing and modification of all record targets without affecting stage levels.

- b. Record target data may be displayed in a summary view, a detailed table orientation or a spreadsheet view, which allows quick data comparisons, move and replace functions.
- c. Changes to blind data shall be automatically stored. Range selection of both record targets and channels shall be supported.

3. Patch Display

- a. Patch shall be used to display and modify the system control channels with their associated library data.
- b. Each channel may be provided with a proportional patch level, curve, label, White Point, swap and invert functions, Live/Dark flag enable/disable, as well as keywords to service Query.
- c. A full library of profiles is provided, with the ability for the user to define "favorites" for fast selection.
- d. Offset functions in patch shall allow selection of channel ranges and shall allow the user to establish a "custom" footprint for any device output.
- e. Custom color wheels, color scrolls and gobo wheels shall be defined in patch. These devices shall be created with a simple table and graphical user interface supported by images of major manufacturers.
- f. RDM discovery and device monitoring shall be supported.
- g. Copy to, Swap and Move functions shall be supported in patch.

4. Setup/Browser

- a. Setup shall access system, user and device configurations.
- b. It shall be possible to partially import show files. Users shall be able to select as much or as little of the show file as required, with renumber tools.
- c. It shall be possible to import ASCII and Lightwright data files. It shall be possible to export as ASCII or .csv.
- d. Setup shall also access show data storage, import, export, print to .pdf and clear functions, as well as show data utilities.
- e. The system shall support programming and playback of real time clock events, including cue, submaster and macro execution at specific times of specified days or at a time based on astronomical events.
- f. A control screen shall be provided for network configuration, selecting date/time, software update controls, selecting functional language and/or keyboard for labeling option, as well as other system level tools.
- g. Available languages for prompts, advisories and help messages shall include English, Bulgarian, German, Spanish, French, Italian, Japanese, Korean, Russian, Chinese, simplified and Chinese, traditional.
- h. Supported keyboards shall include American, United Kingdom, French, German, Italian, Korean, Norwegian, Russian, Slovakian, Turkish, Swiss, Swedish, Finnish and Bulgarian

E. Dimmer Monitoring and Configuration

1. The lighting control system shall provide communication with an ETC Sensor+, Sensor3 or FDX dimming system for remote monitoring and configuration of show specific functions from within the software application.
2. Circuit level configuration and monitoring functions shall include but not be limited to:
  - a. Control mode (dimmable, switched, latch-lock, always on, off or fluorescent).
  - b. Curves
  - c. Control threshold
  - d. Min and Max Scale Voltage
  - e. Preheat
  - f. Scale load
3. Rack status messages shall include but not be limited to:
  - a. State of UL924 panic closure
  - b. DMX port error/failure
  - c. Network error/failure
  - d. A, B, C Phase below 90 or above 139 volts and headroom warning
  - e. Ambient temperatures out of range
4. Circuit status shall include but not be limited to:
  - a. Module type and location
  - b. Output level
  - c. Control Source
  - d. Overtemp
5. Advanced circuit feedback shall include but not be limited to:
  - a. Load higher or lower than recorded value
  - b. DC detected on output
  - c. SCR failed on/off
  - d. Breaker trip
  - e. Module has been removed
  - f. Load failure
  - g. Shutdown due to Overtemp

F. Interface Options

1. The desk shall support a variety of local interfaces.
  - a. AC input

- b. USB (a minimum of seven ports shall be provided for connecting devices such as an Alpha-numeric keyboard, mouse, touch screens, USB Flash drive, etc.)
- c. Ethernet (two ports): 802.3af compliant PSE. Each port shall be individually configurable.
- d. Three Display Port output connectors, supporting monitors at 1280x1024 resolution minimum. Touch or multi-touch support of any/all of these monitors is provided.
- e. Four DMX512A/RDM Ports
- f. Contact Closure Trigger Via D-Sub Connector
- g. OSC and UDP Transmit/Receive

G. Accessories

- 1. ETCpad (ETC Portable Access Device)
- 2. iRFR and iRFR Preview (applications for iPhone, iPod Touch and iPad units)
- 3. aRFR (application for Android devices)
- 4. Net3 Remote Video Interface 3
- 5. 20 Fader or 40 Fader non-motorized fader wings
- 6. 10 Fader or 20 Fader non-motorized fader wings
- 7. Net 3Gateways
  - a. Net3/ETCNet 2 to DMX/RDM Gateways (one to four ports)
  - b. Show Control Gateway
  - c. I/O Gateway with 12 analog inputs, 12 SPDT contact outputs, RD232 interface
- 8. ETCnomad (offline, client and/or backup operation)

H. Synchronized Backup

- 1. An optional Backup system shall consist of one of the following combinations of devices:
  - a. Two networked desks.
  - b. One (or more) desk with one Remote Processor Unit (RPU)
  - c. One (or more) desk with two Remote Processor Units (RPUs)
  - d. One (or more) desk with ETCnomad

I. Physical and Acoustical

1. All operator controls and electronics for a standard system shall be housed in a single desktop unit, not to exceed 44.7" wide, 25" deep, 12" high, weighing 83 pounds.
2. Power shall be 90 – 240V AC at 50 or 60Hz, supplied via a detachable power cord.
3. At typical CPU utilization, the unit shall operate at  $\leq 32$  dBA.

1.21 Power Control System

i. General

1. The installation rack shall be the Sensor3 120V as manufactured by Electronic Theatre Controls, Inc., or equal. The Power Control System enclosure shall consist of up to 48 module spaces.

ii. Electrical

2. Sensor3 racks shall operate at 120V, three phase, four wire + ground, 47-53 or to 57-63 Hz at 800 amps max. Other voltage and phase options are available upon request. Sensor racks shall automatically compensate for frequency variations.
3. during operation. Provisions shall be made for optional amp trap devices for fault current protection. Standard SCCR fault current protection shall be 100,000A.
4. All load and neutral terminals shall accept up to #4 AWG (25mm<sup>2</sup>) wire. Systems providing smaller terminals do not allow contractor wire sizing flexibility and shall be deemed unacceptable.
5. Load terminals shall be located at the front of the wiring cavity. Front access racks having terminals located at the back of the rack or on the side near the back of the rack such that adjacent load cabling may block terminal access shall not be acceptable.

iii. Electronics

6. Power control electronics (CEM3) shall be contained in a single module that can be plug-in capable without use of tools. Power control and dimming systems that require tools for removal of control electronics shall not be acceptable.
7. All data and power input for CEM3 control electronics shall be located on a separately removable/pluggable termination connector on the backplane such that backplane can be replaced without removal and discrete secondary conductor terminations. Systems that require discrete termination of DMX,

Ethernet, power input, and dimmer control output directly on terminals on the control module or pluggable backplane shall not be permitted.

8. The power controller shall directly support the following network protocols:
  - a. Net3 protocol suite including ANSI E1.31 Streaming ACN (sACN)
  - b. ANSI E1.17 Architecture for Control Networks (ACN)Systems that do not support the above listed industry standard ACN protocols for Ethernet setup, control and feedback integrated directly between the power system and control system shall not be deemed acceptable.
9. The power controller shall directly support 2 ports of control input using ANSI E1.11 USITT DMX512-A
10. Control signal connections within the enclosure shall be sent between control module and dimmer/power modules using flat ribbon cables. Systems using cat5 cable and RJ45 connections or discrete hand wired conductors for internal connections between control module and dimmer/power modules shall not be acceptable.
11. System shall provide an optional low voltage connection to maintain power of control electronics through brown out, instantaneous, and sustained power outages. Systems that do not provide optional low voltage backup power connection to the power controller shall not be acceptable.
12. Control electronics shall be housed in a formed steel body with cast-aluminum face panel.

iv. Physical

13. The Sensor3 rack shall be a free-standing, dead-front switchboard, substantially framed and enclosed with 16 gauge, formed steel panels. All rack components shall be properly treated, primed and finished. Exterior surfaces shall be finished in fine-texture, scratch-resistant, epoxy paint. Removable top and bottom panels shall facilitate conduit termination on the 48 module rack. Knockouts shall serve the same purpose on 12 and 24 module racks.
14. Sensor3 racks shall be available in three sizes, with the following dimensions.

c.	SR3-12 (12 module)	25.8"H x 14.8"W x 13.3"D
d.	SR3-24 (24 module)	45.8"H x 14.8"W x 16.8"D
e.	SR3-48 (48 module)	83.1"H x 14.8"W x 22.8"D
15. Racks shall be designed for front access to allow back-to-back or side-by-side installation.
16. Racks shall be designed to allow easy insertion and removal of all modules without the use of tools. Supports shall be provided for precise alignment of modules into power and signal connector blocks. With modules removed, racks shall provide clear front access to all load, neutral and control terminations.

Racks that require removable panels to access load, neutral or control terminations shall not be acceptable.

17. An optional bus bar kit shall be available from the factory to allow adjacent racks to be powered by a single line feed. No soft buss rack-to-rack wiring shall be required. Racks that require discrete cabling to connect adjacent racks shall not be acceptable.
18. Module spaces shall be mechanically keyed to accept only the 20A or below, 50A, or 100A module specified for that space. Racks that allow modules of varying wattages to plug into the same space shall not be acceptable. The rack shall be configurable to accept mixed dimmer types and sizes throughout the rack.
19. Each rack shall provide a lockable full-height door containing an integral electrostatic air filter that shall be removable for easy cleaning. A single low-noise fan shall be located at the top of each rack. Design of the rack and modules shall draw all cool air intake air through the integral electrostatic air filter at the front of the rack, discretely through each module housing and directly out the top of the rack such that exhausted hot air from adjacent modules does not heat the module(s) above, below, or to the side of each other. System designs that draw the same heated air through multiple modules shall not be acceptable.
20. The fan shall maintain the temperature of all components at proper operating levels with dimmers under full load, provided the ambient temperature of the dimmer room does not exceed 40°C/104°F. Racks that do not employ both locking doors and electrostatic air filters shall not be acceptable.
21. The fan shall turn on whenever any circuit in the system is activated. In the event of an over-temperature condition, only the affected dimmer module(s) shall shut down and a message shall appear on the control module LCD. The fan shall remain on during thermal shutdown of individual dimmer modules. Systems that do not include over-temperature sensing and preventative thermal shutdown shall not be acceptable.
22. A fan sensor shall be provided. In the event of momentary fan failure, error message will be displayed and sent remotely over Ethernet to optional logging systems. Systems that do not provide optional system event logging shall not be deemed acceptable.
23. If the ambient room temperature drops below 0°C/32°F or rises above 40°C/104°F, a warning shall appear on the dimmer rack LCD. If the temperature rises above 46°C/115°F, the rack shall shut down until the condition is corrected.
24. A 3 x .5-inch LED status indicator (beacon) shall be mounted in the rack door. The beacon shall be visible throughout a wide viewing angle. In normal operating conditions, this LED is illuminated. If the rack's control module senses an error condition, the beacon shall flash until the error is corrected. An optional indicator shall be available for remote locations. Racks have no external means of visually showing that an error is present shall not be acceptable.

## 1.02 POWER CONTROL ELECTRONICS

1. General

1. The Power Control electronics shall be contained in one plug-in Power Controller. Each power controller shall plug into a dimming cabinet with no need for tools or discrete wire connections. A simple user interface shall be provided for group configuration, testing and diagnostics. The Power Control System shall be Sensor 3 as manufactured by Electronic Theatre Controls, Inc.
2. Power control shall be UL/cUL Listed and CE Marked. Power and dimming control that require tools for removal of control electronics shall not be acceptable.

2. Physical (Control Interface)

3. The control electronics shall be contained in one plug-in module, housed in a formed steel body with cast-aluminum face panel, and self-retaining ejection handles to ease removal from the rack.
4. A backlit eight-line by 20-character graphical LCD shall be provided for system configuration, live control and status display.
5. The following features shall be available in power control to reduce setup and tech times:
  - a. Full number pad shall be provided for quick access to dimmers. Power Control that does not provide 0-9 number pad and logic keys for AND, THRU, and AT for fast access, selection, and control of circuit/dimmer numbers shall not be acceptable.
  - b. Power control shall provide NEXT and LAST buttons to progress through individual circuits/dimmers during pre-show lighting checks for lamp burnouts.
  - c. Shortcut buttons for Setup, About and live control shall be provided. These functions shall be separated in such a way that user intending to check status or settings does not accidentally render their system unusable. These buttons shall also serve to reduce maximum time to access any feature or setting on a single dimmer, range of dimmers or an entire rack. Power control that does not include the above features shall not be acceptable.
6. The front panel shall have five status LED indicators: power, network activity, DMX A, DMX B, and panic state.

3. Control Signals and Physical Communications Media ports

7. The power control shall be provided with an Ethernet control signal input. This input shall be fully configurable with a range of patching and priority programming capabilities. The Ethernet signal shall supply seamless integration between the dimmer racks and both the entertainment and architectural lighting control systems. The Ethernet signal shall also enable remote configuration, playback, file storage and monitoring features on a personal computer on the network. Dimming systems that require Ethernet to DMX translation devices for control of critical show lighting introduce a potential failure point and shall not be acceptable.

8. All data and power input for control electronics shall be located on a separately removable/pluggable termination connector on the backplane such that backplane can be replaced without removal and discrete secondary conductor terminations. Systems that do not support tool-less replacement or that require removal of wires connected directly to the control electronics shall not be acceptable.
9. Dimming systems that require discrete termination of DMX, Ethernet, power input, and dimmer control output directly on terminals on the power control or pluggable backplane shall not be acceptable.
10. DMX connections shall be available with option for pluggable screw or punch-down type terminal. Systems that do not allow this option do not support both DMX over CAT5 and multi-strand conductors shall not be acceptable.
11. Ethernet connection shall be available via standard Cat5 RJ45 connection. System requiring punch down direct to rack or controller cannot be Cat5 system certified and shall not be acceptable.
12. Power Control shall provide a convenience Ethernet uplink to the lighting network at the front face of the control module. Network capable 3<sup>rd</sup> party control and monitoring devices shall be provided full access to control, editing and real time feedback.
13. The following options shall be available to backup all controller setup UL924 Panic configuration, and recorded presets:
  - d. Automatic backup in non-volatile backplane memory
  - e. Automatic backup in non-volatile Controller memory
  - f. 3<sup>rd</sup> party FTP server
  - g. USB storage device pluggable on the controller face panel
  - h. Data shall also be transferable to and from library storage on a personal computer on a per-rack basis
4. Power Controller shall support Class 2 EchoConnect control communications
  - a. The control network shall utilize unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit). Use of Category 5, or better, control network wiring shall also be supported.
  - b. The control network wiring may be bus, loop, home run, star or any combination of these
14. The control network wiring may be bus, loop, home run, star or any combination of these
15. The power controller shall directly support the following network protocols:
  - c. Net3 protocol suite including ANSI E1.31 Streaming ACN (sACN)
  - d. ANSI E1.17 Architecture for Control Networks (ACN)

- e. Systems that do not support the above listed industry standard ACN protocols for Ethernet setup, control, and feedback integrated directly between the power system and control system shall not be deemed acceptable.
  - 16. The power control shall directly support 2 optically isolated ports of ANSI E1.11 USITT DMX512-A for control input. Minimum 2,500V of optical isolation shall be provided between the DMX512 inputs and the electronics. Systems that do not have optical isolation on a prewired factory plug-in device shall not be acceptable.
4. Power Control Features
- 17. The power control shall automatically compensate for frequency variations during operation.
  - 18. Dimmer outputs shall exhibit no oscillating or hunting for levels. Dimmers with the same choke type set to the same level shall output within  $\pm 1V$  of each other, regardless of phase or input voltage.
  - 19. Power control shall maintain proper dimming performance for all line feed frequencies from 47-53Hz and 57-63Hz without flicker or misfire. Shifts in frequencies up to 3 Hz shall not result in flicker or loss of dimming timing. Systems that cannot perform to these frequency tolerances and shifts shall not be acceptable.
  - 20. Dimmer output levels shall be regulated for incoming line voltages. The regulation shall adjust for both RMS voltage changes and deformations in the incoming AC waveform. The power control shall monitor and adjust each dimmer's output to maintain a constant power to the load. Regulation shall maintain the desired output voltage  $\pm 1V$  for the entire operating range (91-139V and 181-259 VAC) with the exception that the maximum output will be no greater than the line voltage minus dimmer insulation loss. The regulation shall compensate for dips and anomalies in the AC waveform on a dimmer-by-dimmer basis. There shall be no interaction between dimmers in the system or any other equipment. The output shall be nominally regulated to 115V/230V appropriate for the market, but shall be field adjustable on a dimmer-by-dimmer basis to allow for varying cable length. Systems that cannot maintain perform to the above stated voltage regulation shall not be acceptable.
  - 21. Power control shall support a rack filled with different types and sizes of dimmer modules. The properties of each dimmer shall be configurable, including dimmer name, output curve, dimmer firing mode, and scale voltage values.
    - f. The output curve selections shall include IES Modified Square, Square, Linear, Modified Linear and a Sensor v2.0 output curve. The power control shall also have the capability of storing up to three custom curves as well as an adjustable preheat level, assignable on a per-dimmer basis.
    - g. Circuit control modes shall include: Always on, Dimmable, Dimmer Doubled, Switched (unregulated on/off with adjustable on-at level), Fluorescent with adjustable threshold and Off.
    - h. Power Control shall support forward or reverse phase firing of appropriate modules.

- i. Dimmers set as Dimmer Doubled shall allow a single dimmer to set two different levels on one dimmer circuit by splitting the AC power into positive and negative half cycles with no resultant DC line current.

Power Control that does not support all above listed adjustments to dimmers on a per circuit basis shall not be acceptable.

- 22. User programmable parameters shall support onsite setup via the local interface in the rack. These parameters shall include, but not be limited to, defining module type, scale voltage for each dimmer, firing mode, curve, dimmer numbering, and DMX512/sACN network port assignments. Systems requiring factory programming shall not be acceptable.
- 23. Hardware settings for rack type, available module types, availability of AF features, and operating voltage shall be configurable at the factory or in the field, and shall not require secondary setup after system commissioning even in the event of power controller replacement.
- 24. Controller shall support two methods of automatic configuration during controller replacement in a rack.
  - j. Use backplane configuration: The backplane shall retain full setup and preset data in. In this recovery mode, when a new power control is inserted, the controller shall automatically come on-line fully functional without any manual intervention.
  - k. Use controller configuration: Override backplane configuration such that replacement modules automatically use the configuration resident in nonvolatile memory of the power control.
- 25. Controller shall be capable of changing rack setup for multiple shows for an entire system with a single update command from a remote PC.
- 26. In the event of data loss each rack shall maintain the last level for a user-programmable time (zero to five minutes or indefinitely) or may be programmed to fade out or to play a specific preset. Systems that do not offer this feature shall not be acceptable.
- 27. The power control shall contain diagnostic routines to allow the user to test and troubleshoot the system. The power control shall also contain a Test/Bypass switch to turn all dimmers on to full for testing. This switch shall bypass all electronics and shall force the fan on. Systems that do not include local control, "all on" control bypass, and diagnostic routines shall not be deemed acceptable.
- 28. The power control shall be able to record up to 64 presets in a rack. Presets shall be user programmable by recording a snapshot of current dimmer levels (as set by the all control sources), by entering dimmer levels on the power control directly or by a combination of both methods. The system shall have the ability to program and activate group-wide presets from the power control, remote station, console, networked computer or handheld device. Presets shall be activated in the default fade time of 2 seconds but shall be have a user-programmable fade time between 0 and 60 minutes.

29. A system-wide panic (emergency UL924) activation circuit shall be provided. Any dimmer in any rack may be assigned to the panic circuit. The panic closure shall be maintained. Upon activation the system shall:
  - l. Force all circuits selected to be included in panic to a master level between 80-100%
  - m. Optionally force all non-panic dimmers to zero
  - n. Provide configurable fade time to and from "emergency" state
  - o. Provide configurable delay to and from "emergency" state
30. DMX A and B as well as the Ethernet DMX (EDMX) data may be patched using a rack start address - assigned sequentially from a starting control channel or patched individually on a per-dimmer basis. Priority may be set per universe for the DMX inputs, and set per universe by the control source for Ethernet input. Each dimmer may have up to six network control inputs with either a highest takes precedence or priority patch. Each dimmer may also then be assigned to one of 16 spaces for additional specific preset control. Each preset shall have a separate priority for maximum flexibility of prioritization. Systems that do not support prioritization of multiple Ethernet sources beyond HTP shall not be acceptable. Systems that do not support the above listed flexibility in control source prioritization shall not be acceptable.
31. Power control shall provide the ability to set a single circuit, all circuits or a range of circuits to a level at the control interface in the rack. Systems that cannot locally control dimmers through local control override shall not be acceptable.
32. The power control shall be capable of monitoring and displaying incoming line voltage for all three phases on the LCD. With installed current sensors, the same display shall show amperage on each phase.
33. The power control shall support security protected access. The user shall be able to program passwords that restrict access, preventing unauthorized use of higher-level functions by unauthorized personnel. Systems that do not provide security protected access to features that can render the system unusable shall not be acceptable.
34. Advanced Features (AF) option shall add an additional sensor in the individual dimmer modules. This option shall allow monitoring of current and output voltage on a dimmer-by-dimmer basis and provide information on lamp burnouts, dimmer status and input voltages.
35. Power control shall allow the user to record the loads of all AF dimmers in the system. The power control shall, during operation, test each AF dimmer, determine its load and compare it to the recorded load. Any change from recorded loads of configured tolerance shall display an error on the power control and any monitoring device on the network. If a dimmer is driven on with no load, an optional message shall be available to notify the console operator and electrician that there is no load.
36. Power control shall support a mobile application which allows users to access limited circuit configuration controls via Wi-Fi connection. The mobile application shall be the ThruPower System Reporter (TPSR) app by ETC.

- p. Mobile application shall select the circuit to configure either by scanning a QR code label applied to circuit distribution or by manual entry of circuit information
- q. Mobile application shall allow users to set the Control Mode of the selected circuit in order to shift a ThruPower module between Dimmable and Switched mode according to the requirement of a connected load
- r. Mobile application shall allow users to activate the circuit test function for the selected module
- s. Power controls which do not support mobile circuit configuration from the plugin location of a supported load shall not be acceptable

5. Connect to Console Communications

37. The Ethernet network shall provide an integral link to connect all racks in the system for remote rack-to-console and rack-to-network device communication of the below listed features of real-time control, configuration, and status/feedback using industry standard ANSI E1.17 ACN lighting protocol. Power control and dimming systems that do not use this protocol shall not be permitted. Reported system errors shall be given ACN access to be cleared remotely at the console with exception of system critical errors that require a person to go directly to the rack to manually clear the exiting fault.

38. Control

- t. E1.31 sACN control
- u. Activate/Deactivate rack presets
- v. Set/Unset circuit levels as overrides to Preset, DMX, and sACN control
- w. Lock relays into On/Off/Remote switching states without patching to a console.
- x. Lock dimmers into non-dim mode with On/Off/Remote switching states without patching to a console.

39. Remote console configuration shall include, but not be limited to, real time reporting and editing the following:

- y. Circuit's control mode
  - 1) Dimmable
  - 2) Switched
  - 3) Latch-lock
  - 4) Always on
  - 5) Off
  - 6) Fluorescent
- z. Curves
  - aa. Control threshold
  - bb. Min Scale Voltage
  - cc. Max Scale Voltage
  - dd. Preheat

- ee. Scale load
- 40. Standard rack feedback - Rack status messages shall include, but not be limited to, real time reporting of the following:
  - ff. Identification
    - 1) Rack type
    - 2) Rack name
    - 3) Rack number
  - gg. State of UL924 panic closure
  - hh. DMX port A or B has an error or has failed
  - ii. Network has an error or has failed
  - jj. Phase A, B or C is below 90 volts
  - kk. Phase A, B or C is above 139 volts
  - ll. Phase A, B or C did not start because it was outside of allowable voltage ranges at power up
  - mm. Phase A, B or C voltage headroom warning
  - nn. Frequency is not 50 or 60 Hz
  - oo. Ambient temperature is below 0°C/32°F
  - pp. Ambient temperature is above 40°C/104°F
  - qq. System Critical-Ambient temperature exceeds 46°C/115°F
  - rr. Configuration memory error
  - ss. Run hours remaining before rack filter needs to be cleaned
  - tt. IP address of the controller in the rack
  - uu. Software version of the controller in the rack
- 41. Standard branch circuit feedback - Ethernet console access of the following circuit status shall be provided:
  - vv. Module type
  - ww. Circuit location
  - xx. Patched circuit addresses
  - yy. Output level
  - zz. Control Source
  - aaa. Overtemp
- 42. Advanced branch circuit feedback - Dimmer Specific status messages shall include, but not be limited to, the following:
  - bbb. Load has dropped below recorded value
  - ccc. Load has raised above recorded value
  - ddd. DC detected on dimmer output

- eee. One SCR has failed on/off
- fff. Dimmer has failed off or circuit breaker has tripped
- ggg. Dimmer has been removed
- hhh. Dimmer load has failed
- iii. Dimmer has shut down due to over temperature

### 1.03 INTELLIGENT BREAKER SYSTEM

#### K. General

- 3. Intelligent breaker system shall be 120V Sensor IQ as manufactured by ETC, Inc., or equal
- 4. Breaker Panels shall be UL508, UL67, and UL924 Listed, and shall be so labeled when delivered
- 5. Breakers shall be UL489 listed and shall be labeled when delivered
- 6. Breaker Panels shall consist of a main enclosure with 12, 24, or 48 pole breaker subpanels, integral control electronics for low voltage terminations and provision for accessory cards
  - a. Up to two accessory cards shall be supported per breaker panel

#### L. Mechanical

- 3. The panel shall be constructed of 16-gauge galvanized steel. All panel components shall be properly treated or finished in fine-textured, scratch resistant paint
- 4. Breaker panels shall be capable of being mounted on the surface of a wall or recessed mounted
- 5. Breaker panels shall be available in 12, 24, and 48 pole configurations
  - a. 12 pole MLO (No provision for main Breaker)
    - 1) 31 inches high, 14.25" wide and 4" deep (with front panel attached)
  - b. 12 pole (with provision to add main breaker)
    - 1) 40.25 inches high, 14.25" wide and 4" deep (with front panel attached)
  - c. 24 pole (with provision to add main breaker)
    - 1) 50.25 inches high, 14.25" wide and 4" deep (with front panel attached)
  - d. 48 pole (with provision to add main breaker)
    - 1) 64 inches high, 20" wide and 5.25" deep (with front panel attached)
- 6. Choice of panel covers shall be available for surface or recess mount applications. This outer panel shall ship complete with a locking door to limit access to electronics and breakers

- a. Optional center-pin reject security screws shall be available for all accessible screws
  - b. Optional recess mount doors shall extend 1" beyond all panel edges to hide wall cut-out
- 7. The unit shall provide interior cover over the control electronics and accessory cards to allow access only to class 2 wiring and prevent direct access to class 1 line voltage components
- 8. The panel shall support up to twelve, twenty-four, or 48 single pole branch circuits
  - a. Branch circuits shall range from 15A to 30A capable of holding full rated load for minimum of three hours continuously
  - b. Two and three-pole circuits shall be supported at decreased density where each pole constitutes one of the available single-pole circuits. Mixing of circuits in any combination shall be supported
- 9. Breakers shall provide manual switching control while power is unavailable to the panel such that critical lighting can be set to an on state, without the need for power to the panel
- 10. Breaker output lugs shall accept 10-14 AWG dual conductor wire
- 11. Breaker output lug shall support solid or stranded 6-14 AWG class B, C, or K copper wire
- 12. Control wiring for DMX, station bus, and Emergency input terminations shall land on a removable headers for contractor installation

M. User Interface

- 3. The user interface shall contain an LCD display with button pad to include 0-9 number entry, up, down back arrow navigation and enter
- 4. Test shortcut button shall be available for local activation of preset, sequence and set level overrides
- 5. The user interface shall have a power status LED indicator (Blue), a DMX status LED indicator (Green), a network status LED indicator (Green) and an LED indicator (red) for errors
- 6. Interface shall allow the backlight to timeout and shall provide user editable options to shut off backlight completely as well as adjust screen contrast
- 7. Ethernet interface shall default to automatic IP through link local and DHCP. Upon receiving IP address, the address of the Network Interface Card (NIC) shall display in the about menu. Static address and settings shall also be possible
- 8. The control interface shall support a USB memory stick interface for uploads of configurations and software updates

9. The user interface shall support power input from an external Uninterruptible Power Supply (UPS) supplying 800W-2400W AC power

N. Functional

3. Panel setup shall be user programmable. The control interface shall provide the following breaker setup features (per circuit):
  - a. Type (1 pole, 2 pole, or 3 pole)
  - b. Name
  - c. Circuit Number
  - d. DMX address
  - e. sACN address
  - f. Space Number
  - g. Circuit Modes
    - 1) Normal (priority and HTP based activation and dimming)
    - 2) Latch-lock
    - 3) Fluorescent
    - 4) DALI
  - h. On threshold level
  - i. Off threshold level
  - j. Include in UL924 emergency activation
  - k. Allow Manual
4. Breaker panels shall support discrete addressing of each breaker. Panels that are restricted to use of start address with sequential addressing, and cannot assign each 0-10V output control to any internal circuit shall not be acceptable
5. The panel shall be capable of switching 6 poles on or off at once, or in a user-selectable delay per breaker using a period of 0.1 to 60 seconds, in 0.1 second increments
6. An Ethernet connection shall provide advanced control of relays over streaming ACN (sACN) and transmit status, control override, and measured energy usage per branch circuit via an internal Web UI or central monitoring interface
  - a. Control electronics shall report the following information per branch circuit.
    - 1) Breaker state (On/Off)
    - 2) Breaker state (Open/Closed)
    - 3) Current draw (In Amps)
    - 4) Voltage
    - 5) Energy usage
  - b. Panels that do not report this information shall not be acceptable.
7. Built-in Control shall include:

- a. Ability to record up to 16 presets in each space from the control panel, connected control stations, or timed events
  - b. Presets shall be programmable by recording current levels (as set by DMX or connected control stations), by entering levels on the control panel directly, manually selecting breaker state on each breaker, or a combination of these methods. From the control panel, stations, or timed events it shall be possible to record values for up to 16 zones per space
  - c. Up to 8 spaces in a single rack for total of up to 16 spaces shall be supported per system or system subnet
  - d. Indication of an active preset shall be visible on the control panel display
  - e. One 16-step sequence per space for power up and power down routines
  - f. The panel shall have a UL924-listed contact input for use in Emergency Lighting systems. The panel shall respond to the contact input by setting included breakers to "on", while setting non-emergency breakers "off". Each breaker can be selected for activation upon contact input
  - g. Upon Data loss the system shall provide options to hold last look infinitely or hold for a configured time period set by the installing technician then fade/switch to the input of the next available priority
  - h. Control electronics shall respond directly to control stations for zone, preset, and sequence control. Systems that require secondary control systems for this functionality are not acceptable
  - i. After power loss, electronics shall be capable of holding the system in its previous state until new level data (DMX, architectural presets, sequences and zones, or local overrides) is received to make each breaker change state
8. The control of lighting and associated systems via timed and Astronomical clock controls
- a. The breaker panel shall allow the activation of presets, sequence, and zone programming of up to 50 time clock events via a built in real and astronomical time clock
  - b. System time events shall be programmable via the control panel
    - 1) Time clock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday
    - 2) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event
    - 3) System shall automatically compensate for regions using a fully configurable daylight saving time
    - 4) Presets shall be assigned to events at the time clock
  - c. The time clock shall support event override
    - 1) It shall be possible to override the timed event schedule from the face panel of the time clock
  - d. The time clock shall support timed event hold
    - 1) It shall be possible to hold a timed event from the face panel of the processor

- 2) Timed event hold shall meet California Title 24 requirements
9. The panel shall receive ESTA DMX512-A control protocol. Addressing shall be set via the user interface button keypad with any circuit patched to any DMX control address
  - a. 2,500V of optical isolation shall be provided between the DMX512 inputs and the control electronics as well as between control and power components
  - b. The breakers shall respond to control changes (DMX or Stations) in less than 25 milliseconds. DMX512 update speed shall be 40Hz
  - c. Setting changes shall be able to be made across all, some, or just one selected breaker in a single action from the face panel
  - d. DMX data loss shall allow for levels/breakers to be held for ever or for a specified time before switching to a lower priority source
  - e. Initial Panel setup

- 1) The breaker panel shall automatically detect the type of breaker or dimmer installed in each location without need for manual configuration of the physical arrangement
- 2) Quick rack setup shall be available to apply address settings across all circuits for rack number, DMX Start Address, sACN universe, and sACN start address
- 3) Emergency Setup Menu shall provide optional delays when emergency is activated or deactivated, and option to turn off non-emergency circuits shall be available. Record function shall allow circuits that are turned on to be added to the emergency setting

O. Electrical

3. Breaker Panels shall be available to support power input from:
  - a. 120/208V three phase 4-wire plus ground
  - b. 120/240V single phase 3-wire plus ground
4. Conduit Entry:
  - a. Feeders:
    - 1) Top or upper 6" of either side
    - 2) Bottom or lower 6" of either side
    - 3) Feeders shall enter through the top or bottom according to the orientation of the enclosure.
    - 4) Feeder entry shall be nearest to the location of the feeder lugs or main breaker.
  - b. Load:
    - 1) Load wiring shall enter through the top or bottom of the enclosure through the surface nearest to the breaker sub panel
    - 2) Load wiring may also enter through left and/or right side provided a low voltage chase is not required through the same area. If class 2 chase is required, a field installable barrier panel shall be provided upon request. The side of the panel where the barrier has been installed shall not permit load wiring
  - c. Low Voltage:
    - 1) Top or upper 6" of either side
    - 2) Bottom or lower 6" of either side
    - 3) For low voltage conduit entry at the breaker end of the cabinet, conduits shall be located at the outer 3" of the top/bottom panel
5. Breaker
  - a. Bus connection type: Stab on
  - b. 1, 2, or three poles
  - c. UL489 listed
  - d. 15 amp, 20 amp, or 30 amp
  - e. 22,000 SCCR; 65,000A series rated with main breaker

- f. High inrush trip curve (matches all Sensor breakers)
  - g. Maintains trip curve through entire thermal range
  - h. Guaranteed not to trip at full load
  - i. Load lugs accept 6-14awg load wiring
  - j. Multi-conductor listed output terminal
  - k. Integral mechanically held air gap relay
  - l. Manual control of relay state using breaker handle w/o power
  - m. Integral current sensing
  - n. Integral position and trip sensing
  - o. Control and status provided by contact pads directly at bottom of the breaker case
  - p. No external wires or connections required for control or feedback
  - q. The breaker shall be capable of switching up to 30A
- 6. The breaker panel shall support a maximum feed size
  - 1) 100 Amps at 12 circuits
  - 2) 200 Amps at 24 circuits
  - 3) 400 Amps at 48 circuits
- b. Breaker panels shall support main circuit breaker options:
  - c. Main breaker options shall be optional and available for purchase upon request
  - d. Main breakers shall be field installable
  - e. Main breakers shall be available in up to 100 Amps for 12 circuit panels, up to 200 Amps for 24 circuit panels, and up to 400A for 48 circuit panels at 120V
  - f. Series SCCR ratings apply as follows with appropriate main breaker:
    - 1) 22,000A or 64,000 at 120/208V
  - g. Main breakers shall allow the following range of wire sizes:
    - 1) Up to 300kcmil at 100A and 200A
    - 2) Up to 2x250kcmil at 400A
  - h. Main Lug input shall support up to 2x250kcmil
  - i. Breaker panel shall support a 500kcmil main lug option for 48-circuit panels
- P. Breaker remote switching ratings
  - 1) Mechanical 1,000,000 cycles
  - 2) 24A Resistive 100,000 cycles
  - 3) 16A Ballast (HID) 75,000 cycles
  - 4) 15A Electronic (LED) 100,000 cycles
  - 5) 15A Tungsten 45,000 cycles
  - 6) 30FLA; 180 LRA Motor Load 50,000 cycles
  - 7) Tested duty cycle: 12 operations (6 cycles) per minute

- 8) Decreasing duty cycle significantly increases switch life
- 9) Isolation: 4000V RMS
- 10) Current reporting accuracy: 5%
- 11) Latching state mechanical relay

Q. Breaker Panel Accessories

- 3. A low voltage 0-10V dimming option shall provide up to 24 0-10v control outputs that are linked to relay circuits within the panel. Each output shall support up to 400mA of current sink per output
- 4. A contact input option shall provide 24 dry contact inputs to be linked for direct or group relay control, to activate a preset, or to activate a sequence. Controller software shall allow for normally open maintained, normally closed maintained, or momentary toggle
- 5. A DALI control option shall provide 24 control loops of broadcast DALI control, with each loop controlling up to 64 DALI devices
- 6. A RideThru option shall provide short-term power backup of control electronics by automatically engaging when power is lost, and recharging when normal power is present
- 7. An Isolated Ground option shall provide each circuit in the panel with a ground terminal that is electrically isolated from the equipment ground
- 8. Main Breaker options shall be available as shown in Section E.4

R. Thermal

- 3. The panel shall be convection cooled. Panels that require the use of cooling fans shall not be acceptable
- 4. The panel shall operate safely in an environment having an ambient temperature between 32°F (0°C) and 104°F (40°C), and humidity between 5-95% (non-condensing)

## 1.04 INTELLIGENT BREAKER SYSTEM

### K. General

3. Intelligent breaker system shall be 120V Sensor IQ as manufactured by ETC, Inc., or equal
4. Breaker Panels shall be UL508, UL67, and UL924 Listed, and shall be so labeled when delivered
5. Breakers shall be UL489 listed and shall be labeled when delivered
6. Breaker Panels shall consist of a main enclosure with 12, 24, or 48 pole breaker subpanels, integral control electronics for low voltage terminations and provision for accessory cards
  - a. Up to two accessory cards shall be supported per breaker panel

### L. Mechanical

3. The panel shall be constructed of 16-gauge galvanized steel. All panel components shall be properly treated or finished in fine-textured, scratch resistant paint
4. Breaker panels shall be capable of being mounted on the surface of a wall or recessed mounted
5. Breaker panels shall be available in 12, 24, and 48 pole configurations
  - a. 12 pole MLO (No provision for main Breaker)
    - 1) 31 inches high, 14.25" wide and 4" deep (with front panel attached)
  - b. 12 pole (with provision to add main breaker)
    - 1) 40.25 inches high, 14.25" wide and 4" deep (with front panel attached)
  - c. 24 pole (with provision to add main breaker)
    - 1) 50.25 inches high, 14.25" wide and 4" deep (with front panel attached)
  - d. 48 pole (with provision to add main breaker)
    - 1) 64 inches high, 20" wide and 5.25" deep (with front panel attached)
6. Choice of panel covers shall be available for surface or recess mount applications. This outer panel shall ship complete with a locking door to limit access to electronics and breakers
  - a. Optional center-pin reject security screws shall be available for all accessible screws
  - b. Optional recess mount doors shall extend 1" beyond all panel edges to hide wall cut-out

7. The unit shall provide interior cover over the control electronics and accessory cards to allow access only to class 2 wiring and prevent direct access to class 1 line voltage components
8. The panel shall support up to twelve, twenty-four, or 48 single pole branch circuits
  - a. Branch circuits shall range from 15A to 30A capable of holding full rated load for minimum of three hours continuously
  - b. Two and three-pole circuits shall be supported at decreased density where each pole constitutes one of the available single-pole circuits. Mixing of circuits in any combination shall be supported
9. Breakers shall provide manual switching control while power is unavailable to the panel such that critical lighting can be set to an on state, without the need for power to the panel
10. Breaker output lugs shall accept 10-14 AWG dual conductor wire
11. Breaker output lug shall support solid or stranded 6-14 AWG class B, C, or K copper wire
12. Control wiring for DMX, station bus, and Emergency input terminations shall land on a removable headers for contractor installation

M. User Interface

3. The user interface shall contain an LCD display with button pad to include 0-9 number entry, up, down back arrow navigation and enter
4. Test shortcut button shall be available for local activation of preset, sequence and set level overrides
5. The user interface shall have a power status LED indicator (Blue), a DMX status LED indicator (Green), a network status LED indicator (Green) and an LED indicator (red) for errors
6. Interface shall allow the backlight to timeout and shall provide user editable options to shut off backlight completely as well as adjust screen contrast
7. Ethernet interface shall default to automatic IP through link local and DHCP. Upon receiving IP address, the address of the Network Interface Card (NIC) shall display in the about menu. Static address and settings shall also be possible
8. The control interface shall support a USB memory stick interface for uploads of configurations and software updates
9. The user interface shall support power input from an external Uninterruptible Power Supply (UPS) supplying 800W-2400W AC power

N. Functional

3. Panel setup shall be user programmable. The control interface shall provide the following breaker setup features (per circuit):
  - a. Type (1 pole, 2 pole, or 3 pole)
  - b. Name
  - c. Circuit Number
  - d. DMX address
  - e. sACN address
  - f. Space Number
  - g. Circuit Modes
    - 1) Normal (priority and HTP based activation and dimming)
    - 2) Latch-lock
    - 3) Fluorescent
    - 4) DALI
  - h. On threshold level
  - i. Off threshold level
  - j. Include in UL924 emergency activation
  - k. Allow Manual
4. Breaker panels shall support discrete addressing of each breaker. Panels that are restricted to use of start address with sequential addressing, and cannot assign each 0-10V output control to any internal circuit shall not be acceptable
5. The panel shall be capable of switching 6 poles on or off at once, or in a user-selectable delay per breaker using a period of 0.1 to 60 seconds, in 0.1 second increments
6. An Ethernet connection shall provide advanced control of relays over streaming ACN (sACN) and transmit status, control override, and measured energy usage per branch circuit via an internal Web UI or central monitoring interface
  - a. Control electronics shall report the following information per branch circuit.
    - 1) Breaker state (On/Off)
    - 2) Breaker state (Open/Closed)
    - 3) Current draw (In Amps)
    - 4) Voltage
    - 5) Energy usage
  - b. Panels that do not report this information shall not be acceptable.
7. Built-in Control shall include:
  - a. Ability to record up to 16 presets in each space from the control panel, connected control stations, or timed events

- b. Presets shall be programmable by recording current levels (as set by DMX or connected control stations), by entering levels on the control panel directly, manually selecting breaker state on each breaker, or a combination of these methods. From the control panel, stations, or timed events it shall be possible to record values for up to 16 zones per space
  - c. Up to 8 spaces in a single rack for total of up to 16 spaces shall be supported per system or system subnet
  - d. Indication of an active preset shall be visible on the control panel display
  - e. One 16-step sequence per space for power up and power down routines
  - f. The panel shall have a UL924-listed contact input for use in Emergency Lighting systems. The panel shall respond to the contact input by setting included breakers to "on", while setting non-emergency breakers "off". Each breaker can be selected for activation upon contact input
  - g. Upon Data loss the system shall provide options to hold last look infinitely or hold for a configured time period set by the installing technician then fade/switch to the input of the next available priority
  - h. Control electronics shall respond directly to control stations for zone, preset, and sequence control. Systems that require secondary control systems for this functionality are not acceptable
  - i. After power loss, electronics shall be capable of holding the system in its previous state until new level data (DMX, architectural presets, sequences and zones, or local overrides) is received to make each breaker change state
8. The control of lighting and associated systems via timed and Astronomical clock controls
- a. The breaker panel shall allow the activation of presets, sequence, and zone programming of up to 50 time clock events via a built in real and astronomical time clock
  - b. System time events shall be programmable via the control panel
    - 1) Time clock events shall be assigned to system day types. Standard day types include: everyday, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday
    - 2) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event
    - 3) System shall automatically compensate for regions using a fully configurable daylight saving time
    - 4) Presets shall be assigned to events at the time clock
  - c. The time clock shall support event override
    - 1) It shall be possible to override the timed event schedule from the face panel of the time clock
  - d. The time clock shall support timed event hold
    - 1) It shall be possible to hold a timed event from the face panel of the processor
    - 2) Timed event hold shall meet California Title 24 requirements

9. The panel shall receive ESTA DMX512-A control protocol. Addressing shall be set via the user interface button keypad with any circuit patched to any DMX control address
  - a. 2,500V of optical isolation shall be provided between the DMX512 inputs and the control electronics as well as between control and power components
  - b. The breakers shall respond to control changes (DMX or Stations) in less than 25 milliseconds. DMX512 update speed shall be 40Hz
  - c. Setting changes shall be able to be made across all, some, or just one selected breaker in a single action from the face panel
  - d. DMX data loss shall allow for levels/breakers to be held for ever or for a specified time before switching to a lower priority source
  - e. Initial Panel setup
    - 1) The breaker panel shall automatically detect the type of breaker or dimmer installed in each location without need for manual configuration of the physical arrangement
    - 2) Quick rack setup shall be available to apply address settings across all circuits for rack number, DMX Start Address, sACN universe, and sACN start address
    - 3) Emergency Setup Menu shall provide optional delays when emergency is activated or deactivated, and option to turn off non-emergency circuits shall be available. Record function shall allow circuits that are turned on to be added to the emergency setting

O. Electrical

3. Breaker Panels shall be available to support power input from:
  - a. 120/208V three phase 4-wire plus ground
  - b. 120/240V single phase 3-wire plus ground
4. Conduit Entry:
  - a. Feeders:
    - 1) Top or upper 6" of either side
    - 2) Bottom or lower 6" of either side
    - 3) Feeders shall enter through the top or bottom according to the orientation of the enclosure.
    - 4) Feeder entry shall be nearest to the location of the feeder lugs or main breaker.
  - b. Load:
    - 1) Load wiring shall enter through the top or bottom of the enclosure through the surface nearest to the breaker sub panel
    - 2) Load wiring may also enter through left and/or right side provided a low voltage chase is not required through the same area. If class 2 chase is required, a field installable barrier panel shall be provided upon request. The side of the panel where the barrier has been installed shall not permit load wiring

- c. Low Voltage:
  - 1) Top or upper 6" of either side
  - 2) Bottom or lower 6" of either side
  - 3) For low voltage conduit entry at the breaker end of the cabinet, conduits shall be located at the outer 3" of the top/bottom panel
- 5. Breaker
  - a. Bus connection type: Stab on
  - b. 1, 2, or three poles
  - c. UL489 listed
  - d. 15 amp, 20 amp, or 30 amp
  - e. 22,000 SCCR; 65,000A series rated with main breaker
  - f. High inrush trip curve (matches all Sensor breakers)
  - g. Maintains trip curve through entire thermal range
  - h. Guaranteed not to trip at full load
  - i. Load lugs accept 6-14awg load wiring
  - j. Multi-conductor listed output terminal
  - k. Integral mechanically held air gap relay
  - l. Manual control of relay state using breaker handle w/o power
  - m. Integral current sensing
  - n. Integral position and trip sensing
  - o. Control and status provided by contact pads directly at bottom of the breaker case
  - p. No external wires or connections required for control or feedback
  - q. The breaker shall be capable of switching up to 30A
- 6. The breaker panel shall support a maximum feed size
  - 1) 100 Amps at 12 circuits
  - 2) 200 Amps at 24 circuits
  - 3) 400 Amps at 48 circuits
  - b. Breaker panels shall support main circuit breaker options:
  - c. Main breaker options shall be optional and available for purchase upon request
  - d. Main breakers shall be field installable
  - e. Main breakers shall be available in up to 100 Amps for 12 circuit panels, up to 200 Amps for 24 circuit panels, and up to 400A for 48 circuit panels at 120V
  - f. Series SCCR ratings apply as follows with appropriate main breaker:
    - 1) 22,000A or 64,000 at 120/208V
  - g. Main breakers shall allow the following range of wire sizes:

- 1) Up to 300kcmil at 100A and 200A
- 2) Up to 2x250kcmil at 400A
- h. Main Lug input shall support up to 2x250kcmil
- i. Breaker panel shall support a 500kcmil main lug option for 48-circuit panels

P. Breaker remote switching ratings

- 1) Mechanical 1,000,000 cycles
- 2) 24A Resistive 100,000 cycles
- 3) 16A Ballast (HID) 75,000 cycles
- 4) 15A Electronic (LED) 100,000 cycles
- 5) 15A Tungsten 45,000 cycles
- 6) 30FLA; 180 LRA Motor Load 50,000 cycles
- 7) Tested duty cycle: 12 operations (6 cycles) per minute
- 8) Decreasing duty cycle significantly increases switch life
- 9) Isolation: 4000V RMS
- 10) Current reporting accuracy: 5%
- 11) Latching state mechanical relay

Q. Breaker Panel Accessories

3. A low voltage 0-10V dimming option shall provide up to 24 0-10v control outputs that are linked to relay circuits within the panel. Each output shall support up to 400mA of current sink per output
4. A contact input option shall provide 24 dry contact inputs to be linked for direct or group relay control, to activate a preset, or to activate a sequence. Controller software shall allow for normally open maintained, normally closed maintained, or momentary toggle
5. A DALI control option shall provide 24 control loops of broadcast DALI control, with each loop controlling up to 64 DALI devices
6. A RideThru option shall provide short-term power backup of control electronics by automatically engaging when power is lost, and recharging when normal power is present
7. An Isolated Ground option shall provide each circuit in the panel with a ground terminal that is electrically isolated from the equipment ground
8. Main Breaker options shall be available as shown in Section E.4

R. Thermal

3. The panel shall be convection cooled. Panels that require the use of cooling fans shall not be acceptable
4. The panel shall operate safely in an environment having an ambient temperature between 32°F (0°C) and 104°F (40°C), and humidity between 5-95% (non-condensing)

PART 2. Unison ERn Series Control Enclosures

2.17 CONTROL ENCLOSURES

- K. The control enclosure shall be the Unison ERn Series Control Enclosure as manufactured by Electronic Theatre Controls, Inc., or equal.
- L. Mechanical
  - 3. The External Processing enclosure shall be a surface mounted panel constructed of 18 gauge formed steel panels with a hinged, lockable full-height door containing an integral electrostatic air filter.
    - a. The enclosure door shall have an opening to allow limited access to the control module face panel.
    - b. Enclosures shall be convection cooled without the use of fans.
  - 4. Control Enclosures shall be sized to accept one or two Control Processors and one or two Station Power Modules, including various options and accessories.
    - a. The Control Enclosure for a single control processor (ERn2) shall support a single Station Power Supply module; The Control Enclosure for 2 control processors (ERn4) shall support a quantity of 2 modules.
  - 5. All enclosure components shall be properly treated and finished.
    - a. Exterior surfaces shall be finished in fine textured, scratch resistant, powder based epoxy paint.
  - 6. Enclosure(s) shall also be available in a 19" rack mounted (RM) version.
    - a. Rack-mounted version shall have an independent enclosure suspension kit, with a full height, locking door/cover attached to the kit.
    - b. Rack-mounted version shall have an opening to access the control module face panel, and openings to view indicators on option modules.
  - 7. Enclosure dimensions and weights (without modules) shall not exceed:
    - a. ERn2 - 15" W x 9" H, 10" D, 15 lb.
    - b. ERn2-RM - 19" W 11"H 10" D, 20 lb.
    - c. ERn4 - 15" W x 14" H x 10" D, 20 lb.
    - d. ERn4-RM - 19" W x 16" H x 10" D, 25 lb.
  - 8. Top, bottom, and side knockouts shall facilitate conduit entry.
  - 9. Enclosures shall be designed to allow easy insertion and removal of all control and option modules without the use of tools.
    - a. Supports shall be provided for precise alignment of modules into power and signal connector blocks.

- b. With modules removed, enclosures shall provide clear front access to all power and control wire terminations.

10. Option Modules

a. Ethernet Switch

- 1) The Control Enclosure shall support an optional 5-port Ethernet Switch, with at least 4 ports supplying Power over Ethernet (PoE).
- 2) The Ethernet Switch module shall be 100BaseTX, auto MDI/MDIX, 802.3af PSE compliant.
- 3) The Ethernet Switch module shall contain power, status, and activity indicators. All indicators shall be visible when the enclosure door is open for both rack and wall mounted ERn.

b. Redundant Power Supply (RRPS)

- 1) The Control Enclosure shall support an optional redundant power supply which shall automatically provide power to the control electronics upon failure or removal of the primary power supply.
- 2) The redundant power supply shall assert itself seamlessly without a loss of power to the control electronics.
- 3) The redundant power supply shall seamlessly remove itself when the primary power supply is reengaged.
- 4) The redundant power supply shall provide visible indication that it is active.

c. Station Bus Repeaters (ERn4 only)

- 1) The Control Enclosure shall support an optional module to expand the station bus length an additional 400 meters, and the station count an additional 30 stations (60 maximum per processor/enclosure)
- 2) Wall-mount and 19" Rack-Mount versions shall also be available to support mid-span insertion away from the Control Enclosure.

d. Station Bus Dual Repeaters (ERn4 only)

- 1) The Control Enclosure shall support an optional module to expand the station bus length to two additional 400 meter segments (a total

of 1200 meters from a single enclosure, and the station count to 60 stations (60 maximum per processor/enclosure).

- 2) Wall-mount and 19" Rack-Mount versions shall also be available to support mid-span insertion away from the Control Enclosure.

11. Accessories

a. RideThru Option (RTO)

- 1) The Control Enclosure shall support an optional, short-term back-up power source for the control electronics.
- 2) RideThru Option (RTO) provides power for controls electronics during brief power outages or drop outs.
- 3) The short-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.
- 4) The short-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.
- 5) The short-term back-up power source shall support the control electronics for at least 10 seconds.

b. BatteryPack Option (BPO)

- 1) The Control Enclosure shall support an optional, long-term back-up power source for the control electronics.
- 2) The long-term back-up power source shall automatically engage upon the loss of normal power, seamlessly transitioning the supply power for the control electronics power to itself.
- 3) The long-term back-up power source shall supply power to the control electronics for at least 90 minutes.
- 4) The long-term back-up power supply shall detect the return of normal power, and seamlessly return the control electronics to normal power.
- 5) A test switch/indicator shall be available without opening the rack door or removal of any modules/components.

M. Electrical

3. External Processing enclosures shall be available in 100, 120, 230 and 240 volt, single-phase configurations.
4. External Processing enclosures shall be completely pre-wired by the manufacturer. The contractor shall provide input and control wiring.
5. External Processing enclosures shall be designed to support the following wire terminations:
  - a. AC (single phase)
  - b. Echelon link power (Belden 8471 or equivalent)
  - c. 24Vdc (2- 16AWG Wire)
  - d. DMX512A Port A (In or Out) (Belden 9729 or equivalent)

- e. DMX512A Port B (In or Out) (Belden 9729 or equivalent)
  - f. RS232 Serial In/Out (Belden 9729 or equivalent)
  - g. Unshielded Twisted Pair (UTP) Category 5 Ethernet
  - h. Contact Closure In (14AWG to 26AWG Wire)
  - i. Contact Closure Out (14AWG to 26AWG Wire)
    - 1) Contact Closure Out shall provide 1A @ 30vDC
6. Station Power Modules
- a. Station power supply modules shall provide LinkPower for at 32 stations and 1.5A@24VDC of Auxiliary (AUX) power.
  - b. Station power repeater modules shall provide LinkPower for 30 stations and 1.5A@24VDC of Auxiliary (AUX) power.
  - c. Station power module shall support over-current/short protection for LinkPower and Aux. LinkPower shall support fault detection on each leg of the balanced data bus.
7. All control wire connections shall be terminated via factory provided connectors.

N. Thermal

- 3. Ambient room temperature: 0-40°C / 32-104°F
- 4. Ambient humidity: 10-90% non-condensing

PART 3. Architectural Control Processor Modules

3.17 STATION PROCESSOR MODULES

- 1. The Station Power Module shall be the Unison Paradigm P-SPM-E Series Station Power Module as manufactured by Electronic Theatre Controls, Inc., or equal.
  - 25. The Station Power Module (SPM) assembly shall be designed for use in DRd Series or ERn Rack Enclosures.
- 2. The SPM shall convert input power into low-voltage (Class II) power with data line and a secondary auxiliary low-voltage line to energize button, button/fader, touchscreen, and interface devices for multi-scene lighting and building control.
- 3. The SPM, in conjunction with a matching Architectural Control Processor (ACP), shall support Echelon LinkPower communications with remote devices, including button, button/fader, touchscreen and interface stations, and shall interoperate with LonMARK-approved third-party devices.
  - 26. The LinkPower network shall utilize polarity-independent, low-voltage Class II twisted pair wiring, type Belden 8471 (unshielded) or Belden 8719 (shielded) or

equivalent. One # 14 AWG drain wire will be required for system not using grounded metal conduit.

27. The LinkPower network shall be topology free. Network wiring may be bus, loop, home run, star or any combination of these.
  28. Link power wiring shall permit a total wire run of 1640 ft. (500m)
    - a. Repeaters allow an additional wire run of 1640 ft. (500m)
    - b. Dual-repeaters allow two additional wire runs of 1640 ft. (500m)
  29. Link power wiring between stations shall not exceed 1313 ft. (400m).
  30. The SPM shall support auxiliary power for certain remote devices, including touchscreen and interface stations, as required by the device.
    - c. The auxiliary power network shall utilize polarity-dependent, low-voltage Class II wiring, consisting of two # 16 AWG wires.
    - d. Auxiliary wiring shall permit a total wire run of 1640 ft. (500m)
      - 1) Repeaters allow an additional wire run of 1640 ft. (500m)
      - 2) Dual-repeaters allow two additional wire runs of 1640 ft. (500m)
    - e. The SPM shall supply 1.25 amps at 24v DC continuously.
4. ACP module electronics shall be convection cooled.
5. Each SPM shall:
31. Supply power for up to 63 button and button/fader stations.
  32. Supply auxiliary power for a similar number of interface stations.
  33. Shall supply auxiliary power for up to four Touchscreen stations, when a like number of other stations are deducted from the total.
    - f. Repeaters and dual-repeaters allow two additional Touchscreens (six total) when a like number of other stations are deducted from the total.

### 3.18 PORTABLE TOUCHSCREEN CONTROL STATIONS

1. The Portable Touchscreen Control Stations shall be the Unison Paradigm Portable Touchscreen P-TS7-P/PE Series Control Stations as manufactured by ETC Inc., or equal.
2. General
  3. Portable Touchscreen stations shall support default and fully graphical control pages.
  4. Portable Touchscreen stations shall operate using graphic buttons, faders and other images on at least 30 separate programmable control pages.

5. Portable Touchscreen stations shall also allow programming of page pass-code, lock out and visibility levels.
6. Portable Touchscreen station shall support connection to the System using an Ethernet network with Power over Ethernet (PoE) or the Unison control station Echelon® Link power network.
7. Portable Touchscreen stations connected to the Unison control station Echelon® Link shall support location awareness to automatically load the configuration required dependent on the connection point to the system

### 3. Mechanical

8. Portable Touchscreen stations shall consist of a seven inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels and 24-bit color depth with a capacitive touch interface.
9. The Portable Touchscreen enclosure and cover shall be constructed of aluminum and finished in a black fine-texture powder coat paint
10. The enclosure shall provide a hinged cover with two positions for the Touchscreen: closed and normal operation.
11. The Portable Touchscreen shall have a protective cover for removable media ports.
12. The Echelon® Link Touchscreen shall include an attached cable with 6-pin Amphenol connector and strain relief to interface with Portable Connector Stations
  - a. Attached Cable shall be 15' in length constructed of ultra-flexible material
  - b. Extension cables up to 100' in length shall be available to extend the cable length to a maximum of 115' total length
13. The Ethernet Network Touchscreen shall include a Neutrik Ethercon Port on the rear of the touchscreen for connection to an Ethernet Network.
  - a. Unit will ship with a 10' Ethercon to RJ-45 cable
  - b. Cables with extended lengths shall be available up to 300' in length.

### 4. Electrical

14. Portable Touchscreens shall be powered entirely by the System network.
15. Portable Touchscreens shall connect to the System using an Ethernet network with Power over Ethernet (PoE) or the Unison control station Echelon® Link power network.
  - a. Ethernet Network
    - 1) Ethernet network shall be 10/100BaseTX, auto MDI/MDIX, 802.3af (PoE) compliant.

- 2) Network shall utilize Unshielded Twisted Pair (UTP) Category 5, or better wiring.
- 3) PoE power consumption shall be PoE Class 2, consuming no more than 6 watts.
- b. Echelon® Link power network.
  - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
  - 2) Touchscreen stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
  - 3) Network wiring may be bus, loop, home run, star or any combination of these.

## 5. Functional

### 16. System

- a. The Portable Touchscreen shall support configuration upload from a Paradigm Processor as proxy
- b. The Touchscreen shall support configuration or firmware upload from local removable media
- c. It shall be possible to connect multiple Portable Touchscreen station to the system at one time

### 17. Setup Mode

- a. There shall be a setup display that is separate from any user-defined configuration
- b. It shall be possible to view and modify connectivity settings
- c. It shall be possible to view status information
- d. It shall be possible to view and modify LCD screen settings
- e. It shall be possible to perform Touchscreen calibration
- f. It shall be possible to view and modify audio settings
- g. The appearance of the setup display shall be standard and not editable
- h. The setup display may be invoked from within the user-defined configuration and/or physical button on the Portable Touchscreen
- i. There shall be a default protected method to invoke the setup display

### 18. Configurations

- a. It shall be possible to have multiple configurations stored within an LCD Station
- b. It shall be possible for Portable Touchscreen Stations connected via the Echelon® Link power network to select a configuration automatically based on the physical connection point of the touchscreen.
- c. Where multiple configurations are stored there shall be a setup menu to allow selection of a configuration.

19. Operation

- a. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Touchscreen controls. System shall allow the control of presets, sequences, macros and time clock events.
  - 1) System presets shall be programmable via Button, Button/Fader or Touchscreen stations, or LightDesigner software.
    - a) Presets shall have a discrete fade time, programmable from zero to 84,600 seconds with a resolution of one hundred milliseconds.
    - b) Presets shall be selectable via Touchscreen stations.
  - 2) System macros and sequences shall be programmable via LightDesigner system software.
    - a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
    - b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
  - 3) System time clock events shall be programmable via the Touchscreen, LightDesigner system software, the processor user interface, or the internal web server.
    - a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
    - b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
  - 4) A Color picker, supporting Hue, Saturation and Brightness (HSB) color selection shall be available for color selection of color changing fixtures and provide visual feedback of the current color produced by the associated fixture.
    - a) The color picker shall be provided with a default layout that requires no user configuration
    - b) The Color Picker shall provide RGB faders in addition to the default HSB color wheel for color selection
    - c) Color picker values shall allow for numerical value input in addition to color wheel and fader control
    - d) The color picker shall be compatible with color mixing systems that use up to seven discrete color control channels
- b. Portable Touchscreen stations shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
  - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, and cue light, or room join/separate.
  - 2) Optional fader functions include master control, individual channel control, fade rate control or preset master control.

- c. Portable Touchscreen stations shall allow programming of station and component electronic lockout levels via LightDesigner.
- d. It shall be possible to adjust LCD contrast and brightness.
- e. It shall be possible to program the station to dim during periods of inactivity.

### 3.19 TOUCHSCREEN CONTROL STATIONS

6. The Touchscreen Control Stations shall be the Unison Paradigm Touchscreen P-TS7 Series Control Stations as manufactured by ETC, Inc., or equal.

#### 7. General

- 34. Touchscreen stations shall support default and fully graphical control pages.
- 35. The Touchscreen station shall operate using graphic buttons, faders and other images on at least 30 separate programmable control pages.
- 36. Touchscreen stations shall also allow programming of page pass-code, lock out and visibility levels.

#### 8. Mechanical

- 37. Touchscreen stations shall consist of a seven inch, backlit liquid crystal display (LCD) with a minimum resolution of 800 by 400 pixels and 24-bit color depth with a capacitive touch interface.
- 38. Touchscreen bezels shall be constructed of cast aluminum finished in a fine texture powder coat.
  - a. Touchscreen shall be available in five standard colors
    - 1) Cream (RAL 9001)
    - 2) Ivory (RAL 1015)
    - 3) Gray (RAL 7001)
    - 4) Black (RAL 9004)
    - 5) Signal White (RAL 9003)
  - b. The bezel shall have no visible means of attachment.
  - c. The bezel shall allow the touchscreen to be installed and removed without the use of tools.
  - d. The bezel shall provide two working positions for the Touchscreen: service and normal operation.
- 39. Touchscreen shall offer optional hinged locking covers
  - e. Locking covers shall be made from cast aluminum and be painted to match standard touchscreen color options
  - f. Locking covers shall allow for viewing of system status on the touchscreen through a smoked Lexan window

- 40. The manufacturer shall provide back boxes for all LCD stations.
  - g. Flush back box for Touchscreens with or without locking covers shall be 7.94" wide x 5.33" high x 3.25" deep
  - h. Surface back box dimensions shall be 8.3" wide x 5.6" high x 2.75" deep
  - i. Surface back box for Touchscreens with locking cover dimensions shall be 10.0" wide x 6.7" high x 2.75" deep

#### 9. Electrical

- 41. Touchscreens shall be powered entirely by the System network.
- 42. Touchscreens shall connect to the System using an Ethernet network with Power over Ethernet (PoE) or the Unison control station Echelon® Link power network.
  - j. Ethernet Network
    - 1) Ethernet network shall be 10/100BaseTX, auto MDI/MDIX, 802.3af (PoE) compliant.
    - 2) Network shall utilize Unshielded Twisted Pair (UTP) Category 5, or better wiring.
    - 3) PoE power consumption shall be PoE class 2, consuming no more than 6 watts.
  - k. Echelon® Link power network.
    - 1) Link power shall utilize low-voltage Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
    - 2) Touchscreen stations shall also require (2) #16 AWG stranded wires for 24Vdc operating power. 24Vdc wiring shall be topology free.
    - 3) Network wiring may be bus, loop, home run, star or any combination of these.
    - 4) Network insulation displacement connectors shall be provided with all stations.

#### 10. Functional

- 43. System
  - l. The Touchscreen shall support configuration firmware upload from a Paradigm Processor as proxy
  - m. The Touchscreen shall support configuration or firmware upload from local removable media
- 44. Setup Mode
  - n. There shall be a setup display that is separate from any user-defined configuration
  - o. It shall be possible to view and modify connectivity settings
  - p. It shall be possible to view status information
  - q. It shall be possible to view and modify LCD screen settings
  - r. It shall be possible to perform Touchscreen calibration

- s. It shall be possible to view and modify audio settings
  - t. The appearance of the setup display shall be standard and not editable
  - u. The setup display may be invoked from within the user-defined configuration and/or physical button on the Touchscreen
  - v. There shall be a default protected method to invoke the setup display
45. Configurations
- w. It shall be possible to have multiple configurations stored within an LCD Station
  - x. Where multiple configurations are stored there shall be a boot menu to allow selection of a configuration
46. Operation
- y. The Unison Paradigm Control System shall be designed to allow control of lighting and associated systems via Touchscreen controls. System shall allow the control of presets, sequences, macros and time clock events.
    - 1) System presets shall be programmable via Button, Button/Fader, Touchscreen, or LightDesigner software.
      - a) Presets shall have a discrete fade time, programmable from zero to 84,600 seconds with a resolution of one hundred milliseconds.
      - b) Presets shall be selectable via Touchscreen stations.
    - 2) System macros and sequences shall be programmable via LightDesigner system software.
      - a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      - b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
    - 3) System time clock events shall be programmable via the Touchscreen, LightDesigner system software, the processor user interface, or the internal web server.
      - a) Time clock events shall be assigned to system day types. Standard day types include: anyway, weekday, weekend, Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. System shall support programming of additional custom or special day types.
      - b) Time clock events shall be activated based on sunrise, sunset, time of day or periodic event. System shall automatically compensate for regions using a fully configurable daylight saving time.
    - 4) A Color picker, supporting Hue, Saturation and Brightness (HSB) color selection shall be available for color selection of color changing fixtures and provide visual feedback of the current color produced by the associated fixture.
      - a) The color picker shall be provided with a default layout that requires no user configuration

- b) The Color Picker shall provide RGB faders in addition to the default HSB color wheel for color selection
  - c) Color picker values shall allow for numerical value input in addition to color wheel and fader control
  - d) The color picker shall be compatible with color mixing systems that use up to seven discrete color control channels
- z. Touchscreen stations shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the Windows-based configuration program.
  - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, and cue light, or room join/separate.
  - 2) Optional fader functions include master control, individual channel control, fade rate control or preset master control.
- aa. Touchscreen stations shall allow programming of station and component electronic lockout levels via LightDesigner.
- bb. It shall be possible to adjust LCD contrast and brightness.
- cc. It shall be possible to program the station to dim during periods of inactivity.

### 3.20 GENERAL NETWORK

#### v. General

- 47. The Electronic Theatre Controls Net3 network shall provide data distribution over TCP/IP Ethernet networks. Data shall be layer 3 routable. Systems using proprietary formats or formats other than 10/100/100Mbit wired Ethernet or non-layer 3 routable networks shall not be accepted.
- 48. Connections shall be made between consoles, face panels, architectural processors, dimmers, Net3 Gateways, and computers over standard Ethernet distribution systems using 100BaseT, 100BaseFL, or greater wiring. All installations shall conform to established Ethernet wiring practice, and installation shall be performed by contractors qualified to do this type of work. All wiring shall be tested at Category 5e or higher for full bandwidth operation to the appropriate IEEE standard.
- 49. The Lighting Control system must be supplied by a single manufacturer and must have seamless integration over Ethernet between the Entertainment and Architectural lighting control.

#### vi. Capacities

- 50. The network shall support DMX routing, patching, and prioritization for up to 63,399 universes (32,767,488 DMX addresses). Each address may be input or output from any port on any DMX gateway in the system. DMX input, routing and output shall be

specifically supported on the system from multiple sources and locations up to the maximum number of gateways supported by the Ethernet topology.

51. The network shall support multiple network hosts including consoles, gateways, dimming racks, computers, file servers, printers, and architectural control processors

with discrete command lines and control. The lighting network shall support multiple venues within a system and discrete systems on the same network.

### 3.21 DIGITAL BUTTON AND FADER STATIONS

#### K. Button and Fader Stations

##### 3. General

- a. The control station shall be the Paradigm Inspire Station Series as manufactured by ETC, Inc., or equal
- b. It shall be a remote station on a LinkConnect network that can recall presets, provide direct zone control, play macros and provide room combine actions for a control system
- c. The station shall consist of a dual function (control/ record) push-button with an integral tri-color backlight for each corresponding button and fader

##### 4. Mechanical

- a. Control stations shall operate using one, two, four, six or eight buttons. A four button with fader station shall also be available
- b. All button stations shall be available with cream, grey, black or white decorator style faceplates
  - 1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard
- c. Stations shall have tri-color backlights for each button and fader
  - 1) Indicators shall utilize a configurable color backlight for active status
  - 2) Indicators shall utilize a configurable color backlight for inactive status to assist in locating stations in dark environments. Stations that do not support a lit inactive or deactivated state shall not be accepted
  - 3) Stations shall support an off backlight state of inactive status when required
- d. All faceplates shall be designed for flush or surface mounting and have no visible means of attachment
- e. Station faceplates shall be constructed of ABS plastic and designed based on a standard decorator style faceplate.
- f. Buttons shall be indelibly laser marked for each button function
- g. Control station electronics shall mount directly behind the faceplate. The entire assembly shall mount into a single gang back box. Back boxes for flush mounted stations shall be industry standard back boxes. The manufacturer shall supply back boxes for surface mounted stations.

##### 5. Electrical

- a. Control station wiring shall be LinkConnect control wiring utilizing low-voltage, Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).

- b. The station shall operate on class 2 voltage provided by the control system via the LinkConnect network.
  - c. Station wiring must be topology free. It may be point-to-point, bus, loop, home run or any combination of these.
  - d. Wiring termination connectors shall be provided with all stations.
  - e. Control stations shall be UL/ cUL listed and CE marked and meet WEEE Compliance
6. Functional
- a. The Control System shall be designed to allow control of lighting and associated systems via Button and Fader controls.
    - 1) System presets shall be programmable via LightDesigner configuration software.
      - a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
    - 2) System macros and sequences shall be programmable via LightDesigner configuration software.
      - a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
      - b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
  - b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.
    - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.
    - 2) Optional fader functions include manual master control, individual zone control, color control fade rate control or preset master control.
- Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

vii. System Configuration and Monitoring

52. Network device configuration shall be via Net3 Gateway Configuration Editor (GCE) software and/or ANSI E1.17 Architecture for Control Networks (ACN).
53. Patch addresses shall support viewing and manipulation via ANSI E1.17 ACN.
  - c. The system shall permit complete user flexibility allowing the system operator to patch each DMX input address to any ANSI E1.31 streaming ACN address, and DMX output to span streaming ACN universes.
  - d. The lighting system shall support assignment of DMX offsets, truncation of DMX universes, and provide choice of DMX port prioritization.
  - e. The lighting system shall support the DD start code extension to ANSI E1.31 which provides priority per address such that multiple control sources can share universes with discrete control per address.
  - f. Lighting systems that do not support the above mentioned address patching capabilities shall not be suitable.
54. The system shall allow assignable labels for all network devices to allow easy identification by system users.
55. Each network device shall have a discrete and unique IP address provided automatically by the software. The user may edit this IP address. Systems that do not support automated IP allocation with IP collision avoidance, and systems that do not allow complete reconfiguration of the above mentioned features over ANSI E1.17 ACN shall not be acceptable.
56. All configuration data for each network device shall be held at the device and system operation shall not require continuous on-line operation of the network configuration software.
57. Lighting console operators shall be able to backup the network configurations in the lighting control console. In the event of a network device failure, the operator shall be able to apply the configuration of the failed device to a replacement device of the same type without manually reentering settings. Systems that do not support configuration backup as described above shall not be accepted.
58. Architectural and Entertainment systems connected to the same network shall be capable of arbitrating control over E1.31 Streaming ACN (sACN) level data. The system shall be capable of alternating control of individual address data between architectural and entertainment systems without intervention by the user. The user shall dictate the conditions under which system shall automatically take control. The network shall allow user override of the selected defaults. Systems which require direct user intervention to allocate control of dimmers between architectural and entertainment lighting systems shall not be accepted.
59. The Net3 network shall allow multiple DMX input sources to be prioritized on the same universe as network native sources using E1.31 Streaming ACN prioritization. Multiple DMX inputs may be assigned to the same streaming ACN address (this provides multi-source control for a particular address). Likewise, the system shall support E1.31 prioritization of multiple simultaneous network sources. Systems that

cannot prioritize multiple DMX inputs and multiple native network sources on a network shall not be deemed suitable.

60. The lighting network shall allow each DMX input address to be assigned a priority on the network allowing each DMX control level coming into the system to participate in full arbitration. Addresses with the highest priority shall have control, with lower priority addresses being ignored. Addresses assigned the same numeric priority, between 1 and 200, shall respond in highest level takes precedence (HTP) manner. The network shall require a valid DMX signal present at the input to initiate prioritization. Systems that do not allow for prioritized HTP for DMX inputs to the network shall not be allowed.

viii. Operational Features

61. Each DMX gateway shall control up to 512 DMX addresses per port, within the confines of up to 63,999 DMX universes (32,747,488 address). The specific DMX data input or output by the gateway shall be configurable by the user.
62. Duplicate outputs of DMX data (DMX splitter) and discrete outputs shall be fully supported.
63. Merging of multiple DMX input sources on a single gateway without gateway with DMX output on the same gateway shall be supported without connection to the network. The gateway shall support assignment of priority to each input source independently
64. File transmission, synchronization and access to software shall be supported.

### 3.22 CONTROL SYSTEM CONFIGURATION SOFTWARE

#### 1. System Configuration

65. The Lighting Control System Configuration software shall be the Net3 Concert software as manufactured by Electronic Theatre Controls, Inc., or equal.

#### 66. Definitions

- a. A system is more than one Net3 or RDM device
- b. A fixture is a controllable entity with one or more attributes
- c. An attribute is a parameter of control such as IP address or dimmer number
- d. A group is a selection of devices that can be stored and recalled
- e. A space is defined area where other system objects reside. A space defines the scope of Control for other objects.
- f. An indicator is a single point of feedback from the system (e.g. LED, Label on LCD)
- g. Linking is the process of associating a logical instance of a device within the configuration with a physical device discovered at runtime

#### 67. Environment

- h. There shall be clipboard functionality (cut, copy, paste) for entire objects, settings, and text.
- i. There shall be undo and redo functionality where persistent changes are made to the System configuration (but not application settings or playback state).
- j. There shall be an auto-backup feature.
- k. The application interface shall be based around (i) a tree-view; (ii) a workspace area; (iii) a properties inspector; (iv) item selector.
- l. It shall be possible to represent data about the workspace area graphically (plan) or in spreadsheet form.
- m. Plan views shall support zoom.
- n. Plan views shall support a layout grid with user-defined spacing and color with associated snap-to-grid functionality.
- o. The properties inspector shall be used to view and modify the properties of one or multiple devices.
- p. It shall be possible to enter user-configurable names in any language supported by their operating system (e.g. encoded as UTF8).
- q. User-configurable names shall be limited to 64 display characters each.
- r. Help functionality shall be accessed from within the application.

#### 68. System Configuration

- s. It shall be possible to create Logical Spaces that contain a subset of devices or objects from a parent logical space, or from the world view.
- t. It shall be possible to add devices by selecting a Fixture Template from the provided library.

- u. It shall be possible to work online with a live system, or offline.
- v. It shall be possible to create a system based on discovery of online devices by generating a topographical network map of all supported, online devices.
- w. It shall be possible to export system configuration data to individual device configuration files
- x. There shall be a wizard to assist with the initial setup of a system including project data entry, and network configuration.
- y. There shall be a process for linking physical and logical devices
- z. There shall be a 2-dimensional plan view that displays devices
- aa. Items displayed on the plan may be arranged using standard graphical interaction methods (e.g. drag-and-drop)
- bb. It shall be possible to import images JPEG, BMP and GIF formats as a background image to the plan view

69. Device Configuration

- cc. There shall be functionality to configure RDM devices by connection through a DMX gateway or other protocol converter.
- dd. There shall be support for configuration of Net3 and ACN based Ethernet devices.
- ee. New devices shall be added using a simple device package import, without the need for a new software version.
- ff. Device configuration shall be supported by editing properties in the property editor, or through use of a purpose built mini-editor.

70. Network

- gg. Shall display a topological view of devices connected
- hh. Can associate a device with a specific view or views
- ii. Shall report online status of all supported devices
- jj. Shall allow for configuration of network properties (IP) of devices
- kk. Shall allow for upload of configuration data to all or individual device or an entire system
- ll. Shall allow for download of configuration data from a single device or an entire system
- mm. Shall allow for download of logging data from connected devices
- nn. Shall provide for performing software upgrades to connected devices
- oo. Shall allow for discovery and linking of devices
- pp. There shall be a mode in which configuration changes are propagated to Processors as they occur without interrupting operation (live edit).

71. Reports

- qq. It shall be possible to generate tabular reports and customize their layout and appearance.
- rr. It shall be possible to print reports.

ss. It shall be possible to export reports to file (e.g. CSV).

## 2. Minimum Computer Requirements

72. The software shall require the following minimum requirements:

tt. Windows 8, Windows7 or Windows XP SP2 operating system

uu. 2 GHz Pentium 4 or better

vv. A minimum of 1 GB system memory

ww. A minimum of 1 GB hard drive space

xx. OpenGL graphics acceleration with a monitor capable of displaying at least 1024 x 768 screen resolution

yy. Keyboard and mouse.

## 3.23 DIGITAL BUTTON AND FADER STATIONS

### K. Button and Fader Stations

#### 3. General

- a. The control station shall be the Paradigm Inspire Station Series as manufactured by ETC, Inc., or equal
- b. It shall be a remote station on a LinkConnect network that can recall presets, provide direct zone control, play macros and provide room combine actions for a control system
- c. The station shall consist of a dual function (control/ record) push-button with an integral tri-color backlight for each corresponding button and fader

#### 4. Mechanical

- a. Control stations shall operate using one, two, four, six or eight buttons. A four button with fader station shall also be available
- b. All button stations shall be available with cream, grey, black or white decorator style faceplates
  - 1) Manufacturer's standard colors shall conform to the RAL CLASSIC Standard
- c. Stations shall have tri-color backlights for each button and fader
  - 1) Indicators shall utilize a configurable color backlight for active status
  - 2) Indicators shall utilize a configurable color backlight for inactive status to assist in locating stations in dark environments. Stations that do not support a lit inactive or deactivated state shall not be accepted
  - 3) Stations shall support an off backlight state of inactive status when required
- d. All faceplates shall be designed for flush or surface mounting and have no visible means of attachment
- e. Station faceplates shall be constructed of ABS plastic and designed based on a standard decorator style faceplate.

- f. Buttons shall be indelibly laser marked for each button function
      - g. Control station electronics shall mount directly behind the faceplate. The entire assembly shall mount into a single gang back box. Back boxes for flush mounted stations shall be industry standard back boxes. The manufacturer shall supply back boxes for surface mounted stations.
  - 5. Electrical
    - a. Control station wiring shall be LinkConnect control wiring utilizing low-voltage, Class II unshielded twisted pair, type Belden 8471 or equivalent, and one #14 ESD drain wire (when not installed in grounded metal conduit).
    - b. The station shall operate on class 2 voltage provided by the control system via the LinkConnect network.
    - c. Station wiring must be topology free. It may be point-to-point, bus, loop, home run or any combination of these.
    - d. Wiring termination connectors shall be provided with all stations.
    - e. Control stations shall be UL/ cUL listed and CE marked and meet WEEE Compliance
  - 6. Functional
    - a. The Control System shall be designed to allow control of lighting and associated systems via Button and Fader controls.
      - 1) System presets shall be programmable via LightDesigner configuration software.
        - a) Presets shall have a discrete fade time, programmable from zero to 1,000 hours with a resolution of one millisecond.
      - 2) System macros and sequences shall be programmable via LightDesigner configuration software.
        - a) Macro and sequence steps shall provide user selectable steps, and allow the application of conditional logic.
        - b) Macro and sequences shall be activated by button, time clock event or LightDesigner software.
    - b. Control components shall be designed to operate default or custom system functions. Components shall operate default functions unless re-assigned via LightDesigner, the software-based configuration program.
      - 1) Optional button functions include: preset selection, manual mode activation, record mode activation, station lockout, raise, lower, macro activation, or room join/separate.
      - 2) Optional fader functions include manual master control, individual zone control, color control fade rate control or preset master control.
- Stations (Button and Button/Fader) shall allow programming of station and component electronic lockout levels via LightDesigner.

### 3.24 DMX ETHERNET GATEWAY – FOUR PORT

- General

73. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX-512 data to be encoded, routed over an Ethernet network and decoded back to DMX-512. The unit shall be a Response Mk2 4-port DMX Gateway as provided by ETC, Inc.

74. Gateways shall communicate over Ethernet directly with at least ETC, Inc.'s entertainment and architectural lighting control products and other Ethernet interfaces.

75. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.

76. The gateway shall support multiple protocols including:

- a. ANSI E1.17 Architecture for Control Networks (ACN)
- b. ANSI E1.31 Streaming ACN (sACN)
- c. ANSI E1.11 USITT DMX512-A
- d. ANSI E1.20 Remote Device Management (RDM)

77. The gateway shall be tested to UL standards and labeled ETL Listed.

78. The gateway shall be RoHS Compliant (lead-free).

79. The gateway shall be CE compliant.

80. The gateway shall have a graphic OLED display and four buttons for identification (soft-labeling), configuration, status reporting and troubleshooting

- e. Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN), or a purpose built software configuration tool.
- f. The OLED display shall show DMX port configuration indication as well as indicate the presence of valid signal.
- g. Gateways that do not indicate port configuration (input/output) and valid data shall not be acceptable.

81. Each gateway shall have power and data activity LEDs on the front of the gateway

- DMX Ports

82. DMX Ports shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.

83. Each DMX port shall be software or locally-configurable for either input or output functionality.

84. DMX input shall be optically-isolated from the gateway electronics.

- 85. DMX Port shall provide at least 500V isolation to ground and the rest of the electronics
- 86. Each port shall incorporate one DMX512-A Connection
- h. Gateways shall be available with the following connection options: 5-pin male XLR, 5-pin female XLR, Ethercon RJ-45, or terminal strip for DMX wiring.
- 87. Network gateways that do not indicate input/ output port configuration or presence of valid data shall not be accepted

- Processor

- 88. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 addresses).
- 89. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 mSec.).
- 90. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility with 3<sup>rd</sup> party DMX devices.

- Mechanical

- 91. The Gateway shall be fabricated of 16-gauge steel, finished in fine-texture, scratch-resistant, black powder coat (RAL 9004).
- 92. The gateway shall support table top use
- 93. The gateway shall support field configuration allowing the Ethernet port to be either on the front or the rear of the unit
- 94. Optional accessories for rack-mount and pipe applications shall be available from the manufacturer. These accessories shall support installation by an end-user

- Power

- 95. Power for the gateway shall be provided over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 7 watts.
- 96. An optional low-voltage DC power input shall be available utilizing an isolated in-line power supply capable of an operating range of 12-24VDC. The Power supply shall be provided by the gateway manufacturer.
- 97. The gateway electronics shall be electrically isolated from the power supplied over the Category 5 (or better) cable.

- Configuration

- 98. The Gateway must support local or remote configuration.

99. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required for configuration, and shall not be required for normal operation of the system.

100. Each port of the DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes.

101. The specific DMX data input or output by the gateway shall be freely configurable by the user.

102. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.

103. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.

104. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway

105. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the PC to be online. Gateways that do not support non-volatile storage of data routing shall not be accepted.

- Network

106. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.

107. All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.

108. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.

109. ANSI E1.17 Architecture for Control Networks (ACN) and streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.

110. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 63,999 universes (32,767,488 addresses) using Streaming ACN (sACN).

i. Any range of DMX addresses may be selected for each universe.

j. Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.

k. Each DMX port shall support its own universe and start address.

111. Gateways shall have built in DMX merger capability on a universe or channel-by-channel basis.

112. Gateways shall support have built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent priorities shall not be accepted.

- Environmental

113. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).

114. The storage temperature shall be -40° to 70°C (-40° to 158°F).

115. The operating humidity shall be 5% - 95% non-condensing.

- Accessories

116. Hanging bracket kit shall allow unit to be mounted in three orientations.

I. U-Bolt or C-Clamp mounting hardware shall be available

117. One E.I.A. rack space mounting bracket kit shall support either one or two complete units and allow for up to eight ports of DMX

118. Front Access Panel kit shall allow the connectors on the rear of the gateway to be accessed from the front of an equipment rack. Options for 5-pin XLR style connectors that support DMX input or output shall be available

119. A Universal Power Supply with international plug-set shall be available. Multiple power supplies shall be able to fit in a vertically stacked power strip.

120. ETC Net3 Concert Configuration and monitoring Software

- System Requirements

121. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by ETC Inc. of Middleton, WI.

### 3.25 DMX ETHERNET GATEWAY – TWO PORT

#### K. General

3. The lighting control gateway shall be a microprocessor-based unit specifically designed to provide DMX-512 control of lighting systems and transport of RDM configuration and status messages. The gateway shall permit DMX-512 data to be encoded, routed over an Ethernet network and decoded back to DMX-512. The unit shall be a Response Mk2 2-port DMX Gateway as provided by ETC, Inc.
4. Gateways shall communicate over Ethernet directly with at least ETC, Inc.'s entertainment and architectural lighting control products and other Ethernet interfaces.
5. Connections shall be made between gateways, consoles, architectural systems, and PCs over standard Ethernet distribution systems using 10/100BaseT.
6. The gateway shall support multiple protocols including:

- a. ANSI E1.17 Architecture for Control Networks (ACN)
  - b. ANSI E1.31 Streaming ACN (sACN)
  - c. ANSI E1.11 USITT DMX512-A
  - d. ANSI E1.20 Remote Device Management (RDM)
7. The gateway shall be tested to UL standards and labeled ETL Listed.
8. The gateway shall be RoHS Compliant (lead-free).
9. The gateway shall be CE compliant.
10. The gateway shall have a graphic OLED display and four buttons for identification (soft-labeling), configuration, status reporting and troubleshooting
  - a. Labeling shall be user configurable using ANSI E1.17 Architecture for Control Network (ACN), or a purpose built software configuration tool.
  - b. The OLED display shall show DMX port configuration indication as well as indicate the presence of valid signal.
  - c. Gateways that do not indicate port configuration (input/output) and valid data shall not be acceptable.
11. Each gateway shall have power and network activity LEDs on the front of the gateway

L. DMX Ports

3. DMX Ports shall comply with the requirements of ANSI E1.11 USITT DMX512-A standards.
4. Each DMX port shall be software-configurable for either input or output functionality.
5. DMX input shall be optically-isolated from the gateway electronics.
6. DMX Port shall provide at least 500V isolation to ground and the rest of the electronics
7. Each port shall incorporate one DMX512-A Connection
  - a. Gateways shall be available with the following connection options: 5-pin male XLR, 5-pin female XLR, or Ethercon RJ-45, for DMX wiring.
8. Network gateways that do not indicate input/ output port configuration or presence of valid data shall not be accepted

M. Processor

3. Each gateway shall have sufficient processing power to manage up to 63,999 universes (32,767,488 addresses).
4. Maximum delay time from input to output shall not be greater than one packet time (approximately 22 mSec.).

5. A minimum DMX update rate of 40Hz shall be sustained under all conditions unless specifically configured for a slower rate for the sake of compatibility with 3<sup>rd</sup> party DMX devices.

N. Mechanical

3. Gateway bezels shall be constructed of cast zinc finished in a fine texture powder coat.
  - a. Gateways shall be available in four standard colors
    - 1) Cream (RAL 9001)
    - 2) Gray (RAL 7001)
    - 3) Black (RAL 9004)
    - 4) Signal White (RAL 9003)
  - b. The bezel shall have no visible means of attachment
4. Gateways shall support surface, flush and portable mounting options
  - a. Flush-mount to industry standard 2-gang back box
  - b. Surface back box dimensions shall be 7.3" wide x 4.8" high x 3.5" deep and available from the manufacturer
  - c. Portable gateway
    - 1) The portable gateway shall include a complete enclosure finished in a black or white fine texture powder coat paint
    - 2) Wiring connections shall be required for connection to the lighting system
      - a) Ethernet connection that supports standard Cat5 patch cables or Ethercon cables. Gateways that do not support the use of Ethercon cables shall not be accepted
      - b) DMX input or output connections using is 5-pin XLR or RJ45 Ethercon style connector
      - c) Optional low-voltage DC power input connection

O. Power

3. Power for the gateway shall be provided over the Category 5 (or better) cable, utilizing IEEE 802.3af compliant Power over Ethernet (PoE). Power consumption using shall not be greater than 4 watts.
4. An optional low-voltage DC power input shall also be available utilizing an isolated in-line power supply capable of an operating range of 12-24vDC. The Power supply shall be optionally provided by the gateway manufacturer.
5. The gateway electronics shall be electrically isolated from the power supplied over the Catagory5 (or better) cable.

P. Configuration

3. The Gateway must support local or remote configuration.

4. Each gateway on the network shall be individually configurable using freely available software configuration tools. The primary configuration tool shall be Net3 Concert configuration software running on a network connected PC. The PC shall only be required for configuration, and shall not be required for normal operation of the system.
5. Each DMX gateway shall control up to 512 DMX addresses, within the confines of 63,999 universes.
6. The specific DMX data input or output by the gateway shall be freely configurable by the user.
7. Duplicate outputs of DMX lines (DMX splitter) and discrete outputs shall be fully supported.
8. Multiple DMX universes may be configured with any length up to 512 total addresses. Any range of DMX input addresses shall support selection and routing to the specified sACN output.
9. Multiple sACN sources may be combined with a priority may be assigned to each source sending data to the gateway
10. All relevant routing information shall be stored in non-volatile memory at each gateway. The system shall recover from a power outage without requiring the PC to

be online. Gateways that do not support non-volatile storage of data routing shall not be accepted.

Q. Network

3. Communications physical layer shall comply with IEEE 802.3i for 10BASE-T, 802.3u for 100BASE-TX and 802.3af for Power over Ethernet specifications.
4. All network cabling shall be Category 5 (or better), conforming to TIA-568A/B, and shall be installed by a qualified network installer.
5. Data transport shall utilize the TCP/IP suite of protocols to transfer the DMX data.
6. ANSI E1.17 Architecture for Control Networks (ACN) and ANSI E1.31 streaming ACN (sACN) shall be supported. Gateways that do not support ANSI E1.17 shall not be acceptable.
7. Switches shall comply with power-over-Ethernet IEEE802.3af, unless a separate in-line power supply is provided.
8. Each DMX gateway shall control up to 512 DMX addresses, per DMX port within the confines of up to 63,999 universes (32,767,488 addresses) using Streaming ACN (sACN).
  - a. Any range of DMX addresses may be selected for each universe.
  - b. Multiple sources shall be supported by prioritized Highest Takes Precedence (HTP with priority). Each source shall support assignment of priority to allow override of default HTP behavior.
  - c. Each DMX port shall support its own universe and start address.
9. Gateways shall have built in DMX merger capability on a universe or channel-by-channel basis.
10. Gateways shall support have built in priority on a per-universe or channel-by-channel basis. Gateways that do not support prioritized merging of multiple network sources at independent priorities shall not be accepted.

R. Environmental

3. The ambient operating temperature shall be 0° to 40°C (32° to 104°F).
4. The storage temperature shall be -40° to 70°C (-40° to 158°F).
5. The operating humidity shall be 5% - 95% non-condensing.

S. Accessories

3. Hanging bracket kit shall allow gateway to be mounted using C-Clamp to U-bolt Hardware.
4. A Universal Power Supply with international plug-set shall be available. Multiple power supplies shall be able to fit in a vertically stacked power strip.

5. ETC Net3 Concert Configuration and monitoring Software

T. System Requirements

3. Provide the quantity and type of gateways required, as scheduled. Gateways and software shall be as manufactured by Electronic Theatre Controls Inc. of Middleton, WI.

3.26 DATA PLUG-IN STATIONS

K. General

3. The Plug-in Stations shall consist of the appropriate connectors required for the functional intent of the system. These stations shall be available with DMX input or output, Remote Focus Unit, Network, or architectural control connectors. Custom control connectors shall be available.

L. Connector Options

3. The following standard components shall be available for Plug-in Stations:
- a. 5-Pin male XLR connectors for DMX input
  - b. 5-Pin female XLR connectors for DMX output
  - c. 6-Pin female XLR connectors for RFU and ETCLink connections
  - d. RJ45 connectors for Network connections - Twisted Pair
  - e. 6-Pin female DIN connectors for Unison connections
  - f. DB9 female serial connector for architectural control from a computer
4. Custom combinations and custom control connections shall be available.

M. Physical

3. Station faceplates shall be .80" aluminum, finished in fine texture, scratch-resistant black powder coat. Silk-screened graphics shall be white.
4. The station panel shall mount into an industry standard back box, depending on size and quantity of connectors. A terminal block shall be supplied for contractor terminations.

#### A. DMX EMERGENCY BYPASS CONTROL

- Where required to trigger special-purpose lighting presets and bypass normal lighting controls during emergency or panic situations, the bypass means shall be the DMX Emergency Bypass Controller (DEBC) as manufactured by ETC, Inc., or equal
- Functional
  - The DMX Emergency Bypass Controller shall be capable of overriding a single universe of ANSI E1.11–2008, USITT DMX512-A control signals from “Normal” to “Bypass” when a trigger signal is detected via a contact closure trigger input
    - (1) The DMX Emergency Bypass Controller shall output to a single DMX output or up to six optically-isolated DMX outputs
    - (2) The DMX Emergency Bypass Controller shall poll the bypass trigger input after a power loss and react upon start up
    - (3) The default or recorded preset shall be recalled immediately on restart if the trigger is also applied at restart
    - (4) Controllers that do not support E1.11–2008 compliant DMX communication shall not be acceptable
  - The DMX Emergency Bypass Controller shall be capable of recording a single DMX preset (snapshot) of 512 channels for recall during “Bypass” mode
  - The DMX Emergency Bypass Controller (DEBC) shall have internally accessible, labeled DIP switches for configuration of:
    - (5) DMX Record Mode
      - (a) All 512 channels (default)
      - (b) Selected channels, snapshot
    - (6) Contact input type
      - (a) Normally open (default)
      - (b) Normally closed
    - (7) Wait Time for Restore incoming DMX (bypass trigger removed)
      - (a) 0 Seconds (default)
      - (b) 10 Second Wait
      - (c) 30 Second Wait
      - (d) 10 Minute Wait
    - (8)
  - The DMX Emergency Bypass Controller shall support a single bypass input using two input modes:
    - (9) Bypass triggering shall be supported via a maintained contact input configurable for normally open (N.O.) or normally closed (N.C.) operation
    - (10) The contact input shall support +12VDC wet input to provide interface with fire alarm or secondary triggering systems. Bypass controllers that do not support a fire alarm input shall not be acceptable.

- Mechanical

- The DMX Emergency Bypass Controller (DEBC) enclosure shall be a surface mounted enclosure with a removable cover, constructed of 16-gauge, formed steel with a removable front cover
  - (11) All components shall be properly treated and finished in fine textured, scratch-resistant, powder coat paint
  - (12) DEBC enclosure shall have a minimum of four keyed mounting holes for wall attachment
  - (13) DEBC enclosure shall have a visible label stating the product name, manufacturer name, indicator functions, control functions, ratings and listings
- The DMX Emergency Bypass Controller (DEBC) enclosure shall provide discrete high and low voltage wiring compartments with voltage barrier
- The DMX Emergency Bypass Controller (DEBC) shall have a single bi-color LED indicator visible from the exterior of the enclosure
  - (14) LED shall indicate Normal state with a “green” color light
    - (a) Normal state illuminates steady green when Power and DMX are present
    - (b) LED Off indicates Power or DMX are not present
  - (15) LED shall indicate Bypass state with a “red” color light
    - (a) Bypass state includes bypass input contact trigger or ‘test’ active
- The DMX Emergency Bypass Controller (DEBC) shall have a single test button accessible from the front of the enclosure without removing any panels
  - (16) The test button shall immediately trigger bypass state for as long as it is held down, and release the bypass state immediately upon release of the button
    - (a) The test button shall be momentary only
    - (b) The test button shall be recessed to prevent accidental triggering
- The DMX Emergency Bypass Controller (DEBC) shall have a single, internally accessible button for DMX Record (snapshot) with an indicator LED for record action
  - (c) The record button shall be momentary only and held for at least 3 seconds before activation to prevent accidental recording
  - (d) The LED indicator will flash rapidly when record function is active
  - (e) The LED indicator will illuminate steady when record function is complete
- The DMX Emergency Bypass Controller (DEBC) dimensions and weights shall not exceed:
  - (17) 9” H x 11” W x 2” D,
  - (18) 8lbs (single output); 14.5lbs (multi-output)

- Electrical

- The DMX Emergency Bypass Controller shall be completely internally pre-wired by the manufacturer
- The contractor shall provide input feed and control wiring to the provided terminals
  - (19) DMX Emergency Bypass Controllers (DEBC) shall support 100 to 277 volt input power, 50/60 Hz, 150mA maximum current
- DEBC shall support labeled terminations for two 24 – 10 AWG solid or stranded power wires
- DEBC shall support one Grounding Lug for 24-14 AWG solid or stranded ground wire
- DEBC shall support labeled, socketed termination connections for DMX Input and DMX Output wiring
  - (20) Terminations shall support Belden 9729 cable or equivalent
    - (a) DMX Termination kits for Belden 9729 shall be supplied with the controller
    - (b) Optional Termination kits for Belden 1583A (or equivalent Category 5 cable) shall be available from the manufacturer
- DEBC shall support labeled, socketed termination for the bypass contact input
  - (21) Termination shall support two, 30-12 AWG low-voltage wires
  - (22) The bypass input shall support a maintained normally open (N.O.) or normally closed (N.C.) dry contact input
  - (23) A +12VDC wet contact input shall also be available for interface to fire alarm systems.
  - (24) DEBC shall support socketed DMX transceiver chips
    - (a) A spare DMX transceiver chip shall be supplied in a labeled, inactive socket
- The DMX Emergency Bypass Controller (DEBC) shall internally switch from the normal DMX input (pass through) to the bypass DMX output using electromechanical relays when triggered
  - (25) The DEBC shall have non-volatile memory for storage of a single recorded sequence of 512 channels
    - (a) The recorded sequence shall persist through power outages
    - (b) The default sequence shall have all 512 channels at “full” if no sequence is recorded
  - (26) The DEBC shall have a DMX baud rate of “Slow” (20 packets per second) for increased compatibility during bypass DMX output
- The DEBC shall be available in two versions capable of output to a single DMX line or up to six optically-isolated DMX lines
- The DMX Emergency Bypass Controller shall be UL and cUL Section 924 LISTED for interaction with similarly listed products

- Thermal

- Ambient room temperature: 0-40°C / 32-104°F
- Ambient humidity: 10-95% non-condensing

3.27 BRANCH CIRCUIT EMERGENCY LIGHTING TRANSFER SWITCH (BCELTS)

K. General

3. The Branch Circuit Emergency Lighting Transfer Switch (BCELTS) shall be the SC1008 as manufactured by ETC, Inc., or equal
4. The BCELTS shall provide automatic transfer of a single branch circuit from normal to emergency power source, when normal power fails
5. The BCELTS shall transfer a lighting load branch circuit from a dimmer/ relay or secondary control output to a second power source in the event of a loss of power to the primary power source, a normal system failure, or activation of a fire alarm
6. The system shall be listed under ANSI / UL1008 Transfer Switch Equipment and comply with ANSI / NFPA 110 Standard for Emergency and Standby Power Systems, and ANSI / NFPA 70 (NEC), including Article 700, 701 and 702 safety

standards. Emergency transfer systems that do not comply with the below stated NEC articles and sections shall not be permitted

a. Satisfies requirements of the National Electrical Code (NFPA 70):

- 1) Article 700 – Emergency Systems
- 2) Article 701 – Legally Required Standby Systems
- 3) Article 702 – Optional Standby Systems
- 4) Section 518.3(C) – Assembly Occupancies
- 5) Section 520.7 – Theatres and Similar Locations
- 6) Section 540.11(C) – Motion Picture Projection Rooms

7. The BCELTS shall transfer a single circuit at 120V or 277V up to 20 Amperes in capacity

L. Transfer Switch

3. The BCELTS shall be a UL1008 transfer switch listed for Emergency Systems (NEC Articles 700 and 701; UL CCN WPWR)

- a. Transfer switches not listed under UL1008 shall not be acceptable
- b. Transfer switches listed under UL1008 for Optional Standby (NEC Article 702; UL CCN WPXT) applications only shall not be acceptable
- c. Automatic Load Control Relays (ALCR) listed under UL924 shall not be acceptable

4. The switch shall be positively latched and unaffected by voltage variations or momentary outages so that constant contact pressure is maintained and temperature rise at the contacts is minimized

5. The switch shall be electrically interlocked to ensure only one position, either Normal or Emergency, is engaged at any time

6. The switch shall be break-before-make to ensure that normal and emergency sources are never interconnected within the unit

7. Built-in fuses shall provide 10,000 Ampere Short Circuit Current Rating (SCCR) on the connected emergency circuit

8. Switch contacts shall withstand transfer without welding, with 180° phase displacement between normal and emergency power sources if both sources are energized

9. Transfer switch contacts shall be rated for mixed loads, including electric discharge lamps and tungsten filament lamps

10. Transfer switch shall be rated for a minimum of 6,000 cycles at full tungsten load

M. Control Circuitry

3. The control circuitry shall direct the operation of the transfer switch

4. A field-configurable normally closed (NC) or normally open (NO) dry contact closure input shall be provided
  - a. Up to (10) BCELTS devices may be connected to a single remote loop
5. The BCELTS shall support transfer of a 0-10V or DALI controlled circuit
  - a. Upon activation of emergency transfer the BCELTS shall break the 0-10V or DALI control circuit, driving connected 0-10V circuits to full output and DALI circuits to their default level.

N. Operation

3. Transfer to alternate emergency supply will occur when normal supply sense voltage drops below 80V when used at 120V or 277V

O. Enclosure

3. The BCELTS shall be mounted in a NEMA 1 interior type enclosure finished in fine- textured epoxy paint
4. The enclosure shall be 8.5"H x 10.5"W x 2.75"D
5. The system shall be provided with an approved overlay mounted on the front of the enclosure, stating, "BRANCH CIRCUIT EMERGENCY LIGHTING TRANSFER SWITCH"
6. The enclosure shall be provided with an approved label indicating that the system is UL1008 LISTED for Emergency Systems

3.28 DMX EMERGENCY BYPASS CONTROL

- ix. Where required to trigger special-purpose lighting presets and bypass normal lighting controls during emergency or panic situations, the bypass means shall be the DMX Emergency Bypass Controller (DEBC) as manufactured by ETC, Inc., or equal
- x. Functional
  122. The DMX Emergency Bypass Controller shall be capable of overriding a single universe of ANSI E1.11–2008, USITT DMX512-A control signals from "Normal" to "Bypass" when a trigger signal is detected via a contact closure trigger input
    - a. The DMX Emergency Bypass Controller shall output to a single DMX output or up to six optically-isolated DMX outputs
    - b. The DMX Emergency Bypass Controller shall poll the bypass trigger input after a power loss and react upon start up
    - c. The default or recorded preset shall be recalled immediately on restart if the trigger is also applied at restart
    - d. Controllers that do not support E1.11–2008 compliant DMX communication shall not be acceptable
  123. The DMX Emergency Bypass Controller shall be capable of recording a single DMX preset (snapshot) of 512 channels for recall during "Bypass" mode

124. The DMX Emergency Bypass Controller (DEBC) shall have internally accessible, labeled DIP switches for configuration of:
  - e. DMX Record Mode
    - 1) All 512 channels (default)
    - 2) Selected channels, snapshot
  - f. Contact input type
    - 1) Normally open (default)
    - 2) Normally closed
  - g. Wait Time for Restore incoming DMX (bypass trigger removed)
    - 1) 0 Seconds (default)
    - 2) 10 Second Wait
    - 3) 30 Second Wait
    - 4) 10 Minute Wait
  - h.
125. The DMX Emergency Bypass Controller shall support a single bypass input using two input modes:
  - i. Bypass triggering shall be supported via a maintained contact input configurable for normally open (N.O.) or normally closed (N.C.) operation
  - j. The contact input shall support +12VDC wet input to provide interface with fire alarm or secondary triggering systems. Bypass controllers that do not support a fire alarm input shall not be acceptable.

xi. Mechanical

126. The DMX Emergency Bypass Controller (DEBC) enclosure shall be a surface mounted enclosure with a removable cover, constructed of 16-gauge, formed steel with a removable front cover
  - k. All components shall be properly treated and finished in fine textured, scratch-resistant, powder coat paint
  - l. DEBC enclosure shall have a minimum of four keyed mounting holes for wall attachment
  - m. DEBC enclosure shall have a visible label stating the product name, manufacturer name, indicator functions, control functions, ratings and listings
127. The DMX Emergency Bypass Controller (DEBC) enclosure shall provide discrete high and low voltage wiring compartments with voltage barrier
128. The DMX Emergency Bypass Controller (DEBC) shall have a single bi-color LED indicator visible from the exterior of the enclosure
  - n. LED shall indicate Normal state with a "green" color light
    - 1) Normal state illuminates steady green when Power and DMX are present
    - 2) LED Off indicates Power or DMX are not present

- o. LED shall indicate Bypass state with a “red” color light
    - 1) Bypass state includes bypass input contact trigger or ‘test’ active
- 129. The DMX Emergency Bypass Controller (DEBC) shall have a single test button accessible from the front of the enclosure without removing any panels
  - p. The test button shall immediately trigger bypass state for as long as it is held down, and release the bypass state immediately upon release of the button
    - 1) The test button shall be momentary only
    - 2) The test button shall be recessed to prevent accidental triggering
- 130. The DMX Emergency Bypass Controller (DEBC) shall have a single, internally accessible button for DMX Record (snapshot) with an indicator LED for record action
  - 3) The record button shall be momentary only and held for at least 3 seconds before activation to prevent accidental recording
  - 4) The LED indicator will flash rapidly when record function is active
  - 5) The LED indicator will illuminate steady when record function is complete
- 131. The DMX Emergency Bypass Controller (DEBC) dimensions and weights shall not exceed:
  - q. 9” H x 11” W x 2” D,
  - r. 8lbs (single output); 14.5lbs (multi-output)

xii. Electrical

- 132. The DMX Emergency Bypass Controller shall be completely internally pre-wired by the manufacturer
- 133. The contractor shall provide input feed and control wiring to the provided terminals
  - s. DMX Emergency Bypass Controllers (DEBC) shall support 100 to 277 volt input power, 50/60 Hz, 150mA maximum current
- 134. DEBC shall support labeled terminations for two 24 – 10 AWG solid or stranded power wires
- 135. DEBC shall support one Grounding Lug for 24-14 AWG solid or stranded ground wire
- 136. DEBC shall support labeled, socketed termination connections for DMX Input and DMX Output wiring
  - t. Terminations shall support Belden 9729 cable or equivalent
    - 1) DMX Termination kits for Belden 9729 shall be supplied with the controller
    - 2) Optional Termination kits for Belden 1583A (or equivalent Category 5 cable) shall be available from the manufacturer

- 137. DEBC shall support labeled, socketed termination for the bypass contact input
  - u. Termination shall support two, 30-12 AWG low-voltage wires
  - v. The bypass input shall support a maintained normally open (N.O.) or normally closed (N.C.) dry contact input
  - w. A +12VDC wet contact input shall also be available for interface to fire alarm systems.
  - x. DEBC shall support socketed DMX transceiver chips
    - 1) A spare DMX transceiver chip shall be supplied in a labeled, inactive socket
- 138. The DMX Emergency Bypass Controller (DEBC) shall internally switch from the normal DMX input (pass through) to the bypass DMX output using electromechanical relays when triggered
  - y. The DEBC shall have non-volatile memory for storage of a single recorded sequence of 512 channels
    - 1) The recorded sequence shall persist through power outages
    - 2) The default sequence shall have all 512 channels at "full" if no sequence is recorded
  - z. The DEBC shall have a DMX baud rate of "Slow" (20 packets per second) for increased compatibility during bypass DMX output
- 139. The DEBC shall be available in two versions capable of output to a single DMX line or up to six optically-isolated DMX lines
- 140. The DMX Emergency Bypass Controller shall be UL and cUL Section 924 LISTED for interaction with similarly listed products

xiii. Thermal

- 141. Ambient room temperature: 0-40°C / 32-104°F
- 142. Ambient humidity: 10-95% non-condensing.

3.29 POWER DISTRIBUTION – CONNECTOR STRIPS

▪ General

143. Connectors shall be available as 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A “U” ground (dual rated “T-slot”); other connectors shall be available as specified

144. Internal wiring shall be sized to circuit ampacity and shall be rated at 125°C

145. Pigtails shall be three-wire type “S” jacketed cable sized for the maximum circuit ampacity

146. Pigtails with 20 amp stage pin connectors shall be terminated using 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket

147. Terminations shall be at one end using feed-through terminals individually labeled with corresponding circuit numbers

- a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire
- b. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire
- c. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire
- d. Terminals that place a screw directly on the wire are not acceptable

148. Connector strips shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings

- e. Connector strips shall have junction brackets on 5’ centers
- f. Brackets shall be 1½” x .188” ASTM A36 steel
- g. Hardware shall be ASTM A307 grade 5

149. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified in the connector strip. Connector strips shall utilize a voltage barrier to accommodate these systems. Low Voltage signals shall enter the connector strip via a strain relief or connector mounted in a separate low voltage terminal box at the specified end of the connector strip. Up to four low voltage cables shall be supported for each connector strip

- h. Connector strips with multiple DMX outputs from the same source shall use DMX pass through assemblies consisting of a 6” panel with the one DMX output connector, one DMX input (Pass Through) connector, one DMX pass through (Bypass) switch, and a label detailing the use of the pass through assembly

- i. The bypass switch shall be used when no DMX devices are present at that location. When activated, the DMX pass through switch shall pass DMX directly through to the next DMX panel on the strip. The pass through switch shall have a mechanical indicator to show the operator that it has or has not been engaged

150. Connector Strips shall be listed by a nationally recognized test lab (NRTL)

▪ Physical

151. Connector strips shall be 6.25" H x 3.3" D and fabricated from 18-gauge galvanized steel and finished in black fine-texture powder coat paint

- j. Covers shall be fabricated from 16-gauge galvanized steel

152. Connector strips shall be available in any length specified in increments of 6" and shipped fully wired with all splicing hardware

153. Pigtails and outlets shall be spaced on 18" centers or as otherwise specified

154. Outlets shall be mounted on individual 3" panels

155. No external terminal boxes shall be required for connector strips with 28 or fewer circuits unless otherwise specified

156. Circuits shall be labeled on the connector strip with 2" lettering

k. Circuit labeling options shall include:

- 1) Circuits shall be labeled on the front side of the connector strip with white lettering on black background labels
- 2) Circuits shall be labeled on front and back sides of the connector strip with white lettering on black background labels
- 3) Circuits shall be labeled on the front side of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
- 4) Circuits shall be labeled on the front and rear sides of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
- 5) Circuits shall be labeled on one side of the connector strip using individual circuit cover plates with lettering engraved in the cover and filled with the specified color
- 6) Circuits shall be labeled using specified labeling per plans and drawings

157. Connector strips shall support optional LED indicators to indicate the presence of power at each local circuit. The indicator shall be red in color and mounted in the connector strip

- l. The LED indicator shall be mounted in the lower right corner of the outlet panel

- m. The LED indicator shall be mounted in the connector strip trough directly below the outlet panel
- n. The LED indicator shall be mounted in the center of the 3" plate directly below the circuit label for pigtail circuits

▪ Junction Boxes

158. Gridiron junction boxes shall be available to accommodate "S" type cable wiring into connector strips mounted to non-fixed locations

159. Junction Boxes shall be fabricated from 16-gauge cold rolled steel with 14 gauge end panels. They shall be finished with fine-textured, scratch-resistant, black powder coat paint. Cover(s) shall be 16-gauge cold rolled steel and hinged to allow mounting in any direction.

3.30 POWER DISTRIBUTION – OUTLET AND PIGTAIL BOXES

K. General

- 3. Connectors shall be available as 20A, 50A and 100A grounded stage pin, 20A twist lock and 20A "U" ground (dual rated "T-slot"); other connectors shall be available as specified
- 4. Pigtails shall be three-wire type "S" jacketed cable sized for the maximum circuit ampacity
- 5. Pigtails with 20 amp stage pin connectors shall be terminated using 12 gauge 4 way indent crimp (with inspection window) type where the wire is inserted and crimped directly in the socket
- 6. Terminations for pigtail connectors shall utilize feed- through terminals individually labeled with corresponding circuit numbers
  - a. 20 amp circuits shall use screwless tension clamp terminals listed for 20 – 8 gauge wire
  - b. 50 amp circuits shall use compression terminals listed for 10 – 1 gauge wire
  - c. 100 amp circuits shall use compression terminals listed for 8 – 2/0 gauge wire
  - d. Terminals that place a screw directly on the wire are not acceptable
- 7. Outlet and pigtail boxes shall be supplied with appropriate brackets and hardware for mounting as shown on the drawings
  - a. Standard mounting options shall include pipe or wall mounting
  - b. Brackets shall be made from ASTM A36 steel
  - c. Hardware shall be ASTM A307 grade 5
- 8. A low voltage distribution system shall be available to incorporate DMX, Ethernet or other protocols as specified in the power distribution box

- a. A voltage barrier shall be used to separate the low voltage wiring for the electrical circuits
- 9. Power distribution equipment shall be listed by a nationally recognized test lab (NRTL)
- L. Physical
  - 3. Outlet and pigtail boxes shall be 6.25" H x 3.3" D and fabricated from 18 gauge galvanized steel and finished in black fine-texture powder coat paint
    - a. Covers shall be fabricated from 16-gauge galvanized steel
  - 4. Outlet and pigtail boxes shall be available in any length specified in increments of 3-inches with a maximum length of up to 3-feet
  - 5. Pigtails and outlets shall be spaced on 18" centers or as otherwise specified
  - 6. Outlets shall be mounted on individual 3" panels
  - 7. Circuits shall be labeled with 1.25" lettering
    - a. Circuit labeling options shall include:
      - 1) Circuits shall be labeled on the front side of the connector strip with white lettering on black background labels
      - 2) Circuits shall be labeled on front and back sides of the connector strip with white lettering on black background labels
      - 3) Circuits shall be labeled on the front side of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
      - 4) Circuits shall be labeled on the front and rear sides of the connector strip with engraved lamacoid labels utilizing white lettering on black background labels
      - 5) Circuits shall be labeled on one side of the connector strip using individual circuit cover plates with lettering engraved in the cover and filled with the specified color
      - 6) Circuits shall be labeled using specified labeling per plans and drawings
  - 8. Outlet and pigtail boxes shall support optional LED indicators to indicate the presence of power at each local circuit. The indicator shall be red in color and mounted in outlet or pigtail box
    - a. The LED indicator shall be mounted in the lower right corner of the outlet panel
    - b. The LED indicator shall be mounted in the bottom of the outlet or pigtail box directly below the outlet panel
    - c. The LED indicator shall be mounted in the cover plate directly below the circuit label for pigtail circuits

3.31 POWER DISTRIBUTION – WALL POCKET

xiv. General

160. The wall pocket shall be a wiring device designed for flush mount installation into the wall.
161. Connectors shall be available as 20A grounded stage pin, 20A twist lock and 20A “U” ground (dual rated “T-slot”); other connectors shall be available as specified.
162. Terminations shall be made at each connector by the installer contractor.
- a. 20 amp circuits shall use tension clamp terminals listed for 20 – 8-gauge wire.
- b. Terminals that place a screw directly on the wire shall not be acceptable.
163. Wall pockets shall be supplied with back box and cover plate
164. The wall pocket back box shall have provisions for an integral voltage barrier for low voltage circuits.
165. Wall pockets shall be listed by a nationally recognized test lab (nrtl).

xv. Physical

166. Wall pocket back boxes shall be 8”H x 12”W x 6”D fabricated from 16-gauge cold rolled steel and finished in black fine-texture powder coat paint.
167. Wall pocket covers shall be constructed of .16-gauge cold rolled steel and finished in black fine-texture powder coat paint.
- c. The cover shall be constructed with integral hinges and four (4) or six (6) cable notches dependant on circuit quantity.
- d. Covers shall be attached to the back box using four (4) mounting holes and included hardware
168. Wall pocket connectors shall be mounted in a connector panel fabricated of 16-gauge steel finished in a low gloss black powder coat paint
- e. The connector plate shall be attached to the Wall Pocket back box.
169. Circuits shall be labeled on the connector strip with 9/16” lettering.
- f. Circuit labeling options shall include:
- 1) Circuits shall be labeled on the front side of the connector panel with white lettering on black background labels.
  - 2) Circuits shall be labeled on the front side of the connector panel with engraved lamicaid labels utilizing white lettering on black background labels.
  - 3) Circuits shall be labeled using specified labeling per plans and drawings.

1.17 WHITE-LIGHT, LIGHT EMITTING DIODE FRAMING MOVING HEAD FIXTURE

K. General

3. The fixture shall be a high-intensity white-light fixture with Cyan, Magenta, Yellow and CTO subtractive color mixing as well as framing shutters. The fixture shall be a SolaFrame 750 by High End Systems or approved equivalent.
4. All LED moving light fixtures shall be provided by a single manufacturer to ensure compatibility.
5. The fixture shall be UL 1573 listed for stage and studio use and comply with EN60598-2-17 standard per CE certification
6. The fixture shall comply with the USITT DMX-512A standard

L. Physical or Mechanical

3. The fixtures structural framing shall be constructed of rugged, 1/8" aluminum, free of burrs and pits and finished with a matte black powder coating.
4. Outer covers of head and yoke shall be constructed of ABS plastic with fine textured black surface and fastened to the head frame with quarter turn fasteners.
5. The fixture dimensions shall be
  - a. 665 mm (26.2") from base of the enclosure, to the tip of the lens baffling. Fixtures that are longer than this dimension shall not be deemed acceptable.
  - b. 445 mm (17.5") across the exterior dimensions of the yolk
  - c. The Electronics enclosure shall be 323 mm (12.7") Wide
  - d. Head length 471.5 mm (18.6 ")
  - e. Fixtures shall weigh 28.6 kg (63 lbs)
6. The fixture shall be able to be either truss mounted or set upright on a stable surface. Fixture shall be suitably designed for operation over or under mounted on a truss perpendicular to the ground as well as outriggered parallel to the ground.
7. The following shall be provided:
  - a. Shutter assembly shall be a four plane system capable of rotating +/- 30° on and fully crossing the beam on each individual shutter blade. Additionally the entire Shutter assembly must rotate +/- 45° .
  - b. The fixture must include seven (7) interchangeable rotating gobos with 30mm outside diameter and 25mm image area. Fixtures that have non-interchangeable gobo patterns shall not be deemed acceptable.
    - 1) Rotating gobo systems must be able to index to any point on the 360° positioning of the gobo.

- 2) Rotating gobos must be interchangeable with glass and metal gobo patterns without permanent or semi-permanent modification to the wheels or cartridges. Fixtures that require adhesive application or removal for gobo interchangeability shall not be deemed acceptable.
- c. CMY (Cyan Magenta Yellow) and CTO (Color Temperature – Orange) subtractive color mixing system seven (7) interchangeable colors including red, blue, green, yellow, orange, purple, and dark blue.
- d. Lens defogging system for preventing atmospheric haze or environmental fog materials from building up and limiting output during operation. Fixtures that do not deploy lens defogging systems shall not be deemed acceptable.
- e. Fixture shall have 540 degrees of pan and 265 degrees of tilt. Pan and tilt must be controlled with 16bit control and utilize encoder sensors to guarantee correct step position.
  - 1) Fixture shall have a pan speed of 2.27s for 360 degree movement
  - 2) Fixture shall have a tilt speed of 1.31s for 180 degree of movement.
  - 3) Pan and tilt locks that stop at 0, 45, and 90 degrees for service and handling. Pan and tilt locks are not intended to be engaged during transport in pre-rigged truss.
- f. A 16 leaf iris which reduces the projection area by 83%.
- g. Frost system which softens the edges of the projection on a surface that applies evenly across the beam and allows for variation in insertion time.
- h. Automated 6-50° zooming lens system.
- i. Animation wheel that allows for continuous and uninterrupted motion in two directions and can be moved in/out of the beam.
- j. Triangular three facet prism for multiplication of breakups and images.
  - 1) Prism must be index able, and continuously rotatable in both clockwise and counterclockwise directions.
8. The yolk arms must have collapsible, spring loaded, handles for fixture handling and manipulation.
9. Power supply, cooling and electronics shall be integral to each unit.
10. The unit shall ship with:
  - a. 5' Neutrik True1 PowerCon™ to wire ferrule as standard
  - b. Two (2) brackets that facilitate attaching standard brackets to the fixture base via ¼ turn thumb screws.

M. Optical

3. The light emitting diode engine shall produce 7000K white light within +/-500K
4. The light engine shall be designed to create a color rendering at greater than 70 CRI
5. The fixture shall produce a minimum of 11,300 field lumens with all LED's at full

6. The unit shall provide, but not be limited to:
  - a. Low gate and beam temperature
  - b. Sharp imaging through a four-plane shutter design
  - c. Sharp Imaging on all gobo Planes and Iris planes
7. The unit shall provide, but not be limited to:
  - a. 6 through 50 degree field angles
  - b. High-quality pattern imaging throughout entire zoom range
  - c. Sharp shutter cuts without halation. Shutter systems that suffer from warping and burnout in normal use shall be deemed unacceptable.
    - 1) No more than 1% distortion curvature on framing blades when measured in the widest possible zoom with sharp edge framing shutters. Systems that have more than 1% curvature shall be deemed unacceptable.
  - d. Adjustable hard and soft beam edges. Systems that fail to soften beam edges while also achieving crisp single edge when desired without blue or brown halation shall be deemed unacceptable.

N. Environmental and Agency Compliance

3. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
4. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use
5. The fixture shall be rated for IP-20 dry location use.
6. When the fixture is stationary, and at full intensity, the fixture may not produce noise in excess of 33 dBA. A fixture that produces noise in excess of 33 dBA when stationary and at full intensity shall be deemed unacceptable.
  - a. At no time may the fixture produce noise in excess of 43 dBA.
    - 1) All dBA numbers above are tested in a test chamber with background noise level of 18.1 dBA.

O. Thermal

3. Fixture shall be equipped with a heat pipe radiant cooling system.
4. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 50,000 hours of use
  - a. Fan speed will be capable of automatically adjusting based on thermal management needs.
    - 1) Fixture will provide three fan speed modes that are selectable via DMX.
  - b. Thermal management shall include temperature sensors within the housing to include:

- 1) LED array circuit board temperatures
    - c. Fixture shall permit monitoring of temperature sensors via a legible LCD multi-line backlit display
    - d. Fixtures that do not provide active thermal monitoring, fan speed controls, and current management of LED circuits shall not be acceptable.
  5. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 45° C (113°F) maximum ambient temperature. During times of storage, the fixture shall be stored in temperatures range of -20C (0°F) to 60C (140°F)
  6. The fixture shall maintain .5m (1.64 feet) distance from any flammable object
  7. The fixture shall maintain a minimum of 1.5m (4.9 feet) to any lighted object.
- P. Electrical
3. The fixture shall be equipped with a 100V to 240V 50/60Hz auto-sensing internal power supply
    - a. Fixture shall draw a maximum of 5.6 amps at 100V and 2.2 amps at 240 V.
  4. The fixture shall support power in and thru operation
    - a. Power in shall be via Neutrik® PowerCon™ True1 input connector
    - b. Power thru shall be via Neutrik ® PowerCon™ True1 output connector
  5. The fixture requires power from a non-dimmer source
  6. Power supply outputs shall have self-resetting current-limiting protection
  7. Power supply shall have power factor correction greater than 0.97 from 90 VAC to 265 VAC.
- Q. LED Emitters
3. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
    - a. Appotronics is the sole manufacturer of approved emitter engines.
  4. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
  5. All LED fixtures (100% of each lot) shall undergo a minimum 12-hour burn-in test during manufacturing.
  6. LED system shall comply with all relevant patents
  7. Fixtures shall have PWM frequency up to 16,000hz to avoid flicker on camera
- R. Calibration

3. Fixture shall be calibrated at factory to achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
  - a. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency.

S. Color

3. The fixture shall utilize a minimum of 52 LED emitters
4. The fixture shall be available in specialized LED arrays as outlined below:
  - a. Ultra-Brite 7000k white light engine
    - 1) White LED Engine calibrated and binned to achieve 7000k (+/- 500k).
      - a) Measured brightness of Ultra-brite 7000k engine shall be greater than 11,300 Lumens when tested in an integrating sphere.
5. Fixture must have a subtractive color mixing system utilizing eight (8) dichroic color flags, controlled in pairs, to linearly subtract the following colors out of fixtures light output.
  - a. Cyan
  - b. Magenta
  - c. Yellow
  - d. Color Temperature – Orange
6. Fixture must have semi trapezoidal dichroic glass color segments on a single wheel that transmit the following colors. Dichroics must be replaceable without removal or application of adhesive.
  - a. Red
  - b. Green
  - c. Blue
  - d. Yellow
  - e. Orange
  - f. Purple
  - g. Dark Blue

T. Dimming

3. The LED system shall use 16-bit DMX control techniques for high-resolution dimming.
4. Dimming curves shall be optimized for smooth dimming over longer timed fades.
5. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)

6. LED control shall be compatible with broadcast equipment in the following ways:
  - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment

U. Control and User interface

3. Ethernet compatible with support for ANSI1.31 Streaming ACN and ArtNet protocols
4. Fixture must provide an internal ethernet switch that supports both active and passive data pass-through.
5. Fixtures shall be support protocol conversion from Ethernet to DMX output and also conversion from DMX input to Ethernet output.
6. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors
7. The fixture shall be compatible with the ANSI RDM E1.20 standard
  - a. All fixture functions shall be accessible via RDM protocol for modification from suitably equipped control console
  - b. Temperature sensors within the luminaire shall be viewable in real time via RDM.
  - c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
8. The fixture shall be equipped with multi-line color LCD display for easy-to-read status reports and configuration changes.
  - a. Display must have a feature to battery power the menu structure when the fixture is unplugged to allow fixture settings to be adjusted, including DMX.
9. The fixture shall be equipped with a six-button user-interface
10. The fixture may offer no more than a single DMX control profile.
  - a. Fixture DMX Control Profile will have 47 channel control.

PART 1. Automated Lighting

1.17 ADDITIVE COLOR MIXING, LIGHT EMITTING DIODE MOVING HEAD FIXTURE

K. General

3. The fixture shall be a high-intensity additive color mixing fixture with Red, Green, Blue, and White LEDs. The fixture shall be a SolaPix 7 by High End Systems or approved equivalent.
4. All LED moving light fixtures shall be provided by a single manufacturer to ensure compatibility.

5. The fixture shall be UL 1573 listed for stage and studio use and comply with EN60598-2-17 standard per CE certification

6. The fixture shall comply with the USITT DMX-512A standard

L. Physical or Mechanical

3. The fixtures structural framing shall be constructed of rugged, 1/8" aluminum, free of burrs and pits and finished with a matte black powder coating.

4. Outer covers of head and yoke shall be constructed of ABS plastic with fine textured black surface and fastened to the head frame with quarter turn fasteners.

5. The fixture dimensions shall be

- a. 406 mm (16") from base of the enclosure, to the tip of the lens baffling
- b. 296 mm (11.6") across the exterior dimensions of the yolk
- c. The Electronics enclosure shall be 220 mm (8.7") Wide
- d. Head length 186 mm (7.3")
- e. Fixtures shall weigh 9.1 kg (20.0 lb)

6. The fixture shall be able to be either truss mounted or set upright on a stable surface. Fixture shall be suitably designed for operation over or under mounted on a truss perpendicular to the ground as well as outrigged parallel to the ground.

7. The following shall be provided:

- a. RGBW (Red Green Blue and White) additive color mixing system with electronically mixed CTO.
- b. Individual control over each LED cell with Red, Green, Blue, and White Parameters.
- c. An onboard LED Effects engine that allows control of four individual color segments with speed and fade control.
- d. Fixture shall have 540 degrees of pan and 265 degrees of tilt. Pan and tilt must be controlled with 16bit control and utilize encoder sensors to guarantee correct step position.
  - 1) Fixture shall have a pan speed of 1.2s for 360 degree movement
  - 2) Fixture shall have a tilt speed of 0.58s for 180 degree of movement.
  - 3) Pan and tilt locks that stop at 0, 45, and 90 degrees for service and handling. Pan and tilt locks are not intended to be engaged during transport in pre-rigged truss.
- e. Automated 4.5 - 60° zooming lens system.
- f. Anti-haze nano coating applied to the internal side of each lens to prevent atmospheric buildup.

8. Power supply, cooling and electronics shall be integral to each unit.

9. The unit shall ship with:

- a. 5' Neutrik PowerCon™ to wire ferrule as standard
- b. Two (2) brackets that facilitate attaching standard brackets to the fixture base via ¼ turn thumb screws.

M. Optical

- 3. The fixture shall produce up to 5,500 field lumens with all LED's at full and at room temperature.
- 4. The unit shall provide, but not be limited to:
  - a. Soft edge projection with a 2:1 fall off ration.
  - b. Semi-hard edge in narrow beam projection.
- 5. The unit shall provide, but not be limited to:
  - a. 4.5 through 60 degree field angles

N. Environmental and Agency Compliance

- 3. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
- 4. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use
- 5. The fixture shall be rated for IP-20 dry location use.

O. Thermal

- 3. Fixture shall be equipped with a passive radiant cooling system.
- 4. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 20,000 hours of use
  - a. Fan speed will be capable of automatically adjusting based on thermal management needs.
    - 1) Fixture will provide two fan speed modes that are selectable via DMX.
    - 2) Fixture will also include a user adjustable continuous fan speed control, linearly selectable via DMX.
  - b. Thermal management shall include multiple temperature sensors within the housing to include:
    - 1) LED array circuit board temperatures
    - 2) Power supply temperatures
  - c. Fixtures that do not provide active thermal monitoring and current management of LED circuits shall not be acceptable.
- 5. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature. During times of storage, the fixture shall be stored in temperatures range of -20C (0°F) to 60C (140°F)

6. The fixture shall maintain .1m (3.94 inches) distance from any flammable object
7. The fixture shall maintain a minimum of 2m (6.6 feet) to any lighted object.

P. Electrical

3. The fixture shall be equipped with a 100V to 240V 50/60Hz auto-sensing internal power supply
  - a. Fixture shall draw a maximum of 4.1 amps at 100V and 1.7 amps at 240 V.
4. The fixture shall support power in and thru operation
  - a. Power in shall be via Neutrik® powerCON™ TRUE1 input connector
5. The fixture requires power from a non-dimmer source
6. Power supply outputs shall have self-resetting current-limiting protection

Q. LED Emitters

3. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
  - a. Osram are the sole manufacture of approved emitter engines.
4. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
5. All LED fixtures (100% of each lot) shall undergo a minimum 12-hour burn-in test during manufacturing.
6. LED system shall comply with all relevant patents
7. Fixtures shall have PWM frequency of 16,000hz to avoid flicker on camera

R. Color

3. The fixture shall utilize specialized LED arrays as outlined below:
  - a. Additive Red, Green, Blue, and White LEDs in a hexagonal pattern achieving an excess of 5,600 lumens in integrating sphere testing.
4. Fixture must have an electronically calibrated CTO channel that limits the intensity of the Red, Green, Blue, and White LED channels to control the fixture color temperature output between 2800 to 8000k.

S. Dimming

3. The LED system shall use 16-bit DMX control techniques for high-resolution dimming.
4. Dimming curves shall be optimized for smooth dimming over longer timed fades.

5. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
  6. LED control shall be compatible with broadcast equipment in the following ways:
    - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
- T. Control and User interface
3. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors and In and Thru 3-pin XLR connectors.
  4. The fixture shall be compatible with the ANSI RDM E1.20 standard
    - a. All fixture functions shall be accessible via RDM protocol for modification from suitably equipped control console
    - b. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
  5. The fixture shall be equipped with multi-line color LCD display for easy-to-read status reports and configuration changes.
    - a. Display must have a feature to battery power the menu structure when the fixture is unplugged to allow fixture settings to be adjusted, including DMX.
  6. The fixture shall be equipped with a six-button user-interface
  7. The fixture must offer individual control over base and Pixel sections of fixture profile
    - a. Individual control must include separate protocols and control sources. Fixtures that cannot simultaneously control different fixture modules by an RS-485 source and an Ethernet source will not be deemed acceptable.
  8. Fixture must have a user controllable effects system that generates animated effects using up to four user defined colors. Animation speed and fade control also must be user definable on the fixture.

PART 1. Automated Lighting

1.17 COLOR MIXING LIGHT EMITTING DIODE MOVING HEAD SPOT FIXTURE

K. General

3. The fixture shall be an additive color-mixing high-intensity LED illuminator with DMX control of intensity, color, pan, tilt, and pattern projection. The fixture shall be a Relevé Spot by ETC or approved equivalent.
4. All LED moving light fixtures shall be provided by a single manufacturer to ensure compatibility.
5. The fixture shall be UL 1573 listed for stage and studio use and comply with EN60598-2-17 standard per CE certification.

6. The fixture shall comply with the USITT DMX-512A standard.

L. Physical or Mechanical

3. The fixture's structural framing shall be constructed of rugged, 3/32" aluminum, free of burrs, pits, and finished with non-reflective coating.
4. Outer covers of head and yoke shall be constructed of ABS plastic with fine textured black surface and fastened to the head frame with captive fasteners.
5. The fixture dimensions shall be:
  - a. 803 mm (31.6") from base of the enclosure to the tip of the lens baffling.
  - b. 477 mm (18.8") across the exterior dimensions of the yoke.
  - c. The electronics enclosure shall be 330mm (13") wide.
  - d. Head length 589 mm (23.2").
  - e. The fixture shall weigh 31.75 kg (70lbs).
6. The fixture shall be able to be either truss-mounted or set upright on a stable surface. Fixture shall be suitably designed for operation over or under mounted on a truss perpendicular to the ground as well as outrigger parallel to the ground.
7. The following shall be provided:
  - a. The fixture must include five (5) interchangeable rotating gobos. Fixtures that have non-interchangeable gobo patterns shall not be deemed acceptable.
    - 1) Interchangeable rotating gobos shall have an outside diameter of 45 mm, image diameter of 36mm, and accept 0.5mm stainless steel or 1.1mm Glass Borofloat® gobos.
    - 2) Rotating gobo systems must be able to index to any point on the 360° positioning of the gobo.
  - b. The fixture shall have 540 degrees of pan and 270 degrees of tilt. Pan and tilt must be controlled with 16 bit control and utilize absolute position encoder sensors to guarantee correct step position.
    - 1) The fixture shall have a pan speed of 3.6s for 180 degree movement.
    - 2) The fixture shall have a tilt speed of 3.0s for 180 degree of movement.
    - 3) Pan and tilt locks that stop at 0, 45, and 90 degrees for service and handling. Pan and tilt locks are not intended to be engaged during transport in pre-rigged truss.
  - c. A twenty (20) leaf iris which reduces the projection area by 93%.
  - d. Frost system which softens the edges of the projection with a dual-flag surface that applies evenly across the beam and allows for variation in insertion time without reflections or uneven distribution of diffusion.
  - e. Automated 18-54° zoom and focus lens system.

- f. Rotating fixed pattern wheel shall allow for animation in two directions and shall contain an effect pattern made up of at least six (6) unique and continuous breakup patterns. Fixtures with animation wheels that are made up of a single pattern shall not be deemed acceptable.
  - 8. The yoke arms must have fixed handles for fixture handling and manipulation. Fixtures with no handles on the yoke arms shall not be deemed acceptable.
  - 9. Power Supply, cooling, and driver electronics shall be integral to each fixture.
  - 10. Power supply module shall be easily removable and user replaceable.
  - 11. Control/UI module shall be easily removable and shall have the option for battery power to allow fixture settings to be adjusted while module is removed.
  - 12. The fixture shall ship with:
    - a. 152cm / 5' Neutrik® powerCON™ to wire ferrule as standard.
    - b. Two (2) rail design clamp brackets that facilitate attaching standard hanging hardware to the fixture base.
  - 13. Available options shall include but not be limited to:
    - a. Grounded stage pin, or twist-lock type-equipped power leads.
    - b. Neutrik® powerCON™ to Neutrik® powerCON™ cables for fixture power linking.
- M. Optical
  - 3. The fixture shall produce up to 6,000 field lumens with all LEDs at full and in a wide zoom angle.
  - 4. The fixture shall provide, but not be limited to:
    - a. Low gate and beam temperature.
    - b. Sharp imaging on all gobo planes and iris planes.
  - 5. The fixture shall provide, but not be limited to:
    - a. 18 through 54 degree field angles.
    - b. High-quality pattern imaging.
- N. Environmental and Agency Compliance
  - 3. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
  - 4. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use.
  - 5. The fixture shall be rated for IP20 dry location use.
- O. Thermal

3. The fixture shall be equipped with a cooling fan.
4. The fixture shall utilize advanced thermal management systems and maintain LED life to an average of 70% intensity after 35,000 hours of use.
  - a. Fan speed shall be capable of automatically adjusting based on thermal management needs.
    - 1) The fixture shall provide three fan speed modes that are selectable via DMX and RDM.
  - b. Thermal management shall include multiple temperature sensors within the housing to include:
    - 1) LED array circuit board temperatures.
    - 2) LED driver circuit board temperatures.
  - c. Fixtures that do not provide active thermal monitoring and current management of LED circuits shall not be acceptable.
5. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.
6. The fixture shall have droop compensation to prevent thermal shift of color or intensity.
7. In a room at room Temperature, while in any stationary position, and at full intensity the Relevé Spot is rated at a maximum of:
  - a. Direct Control Mode : 34.6 dBA
  - b. Standard Mode: 32.3 dBA
  - c. Fixtures that exceed 35 dBA in these same environmental conditions shall not be acceptable.

P. Electrical

3. The fixture shall be equipped with a 100VAC to 240VAC 50/60Hz auto-sensing removable power supply module.
  - a. The fixture shall draw a maximum of 2.9A at 100VAC and 1.2A at 240VAC.
4. The fixture shall support power in and thru operation.
  - a. Power in shall be via Neutrik® powerCON™ input connector.
  - b. Power thru shall be via Neutrik ® powerCON™ output connector.
  - c. The fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker.
5. The fixture requires power from a non-dimmed source.
6. Power supply outputs shall have self-resetting current-limiting protection.

Q. LED Emitters

3. The fixture shall contain a minimum of four different LED colors to provide color characteristics, as described in the color section below.

4. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
  - a. The fixture shall utilize Luxeon® C LED emitters.
5. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
6. LED emitters shall be rated for nominal 35,000-hour L70 rating.
7. All LED fixtures (100% of each lot) shall undergo a minimum 12-hour burn-in test during manufacturing.
8. LED system shall comply with all relevant patents.

R. Calibration

3. The fixture shall be calibrated at factory to achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins.
  - a. Calibration data shall be stored on the control card as a permanent part of on-board operating system.
  - b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency.
  - c. Fixtures not offering LED calibration shall not be acceptable.

S. Color

3. The fixture shall utilize a minimum of 52 LED emitters.
  - a. These emitters shall be made up of red, green, indigo, and lime.

T. Dimming

3. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
4. The fixture shall utilize an incandescent dimming curve.
5. Dimming curve shall be optimized for smooth dimming over longer timed fades.
6. The LED system shall be digitally driven using high-speed pulse width modulation (PWM).
7. LED control shall be compatible with broadcast equipment in the following ways:
  - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment.
  - b. PWM shall be capable of being set via UI and RDM to either 1.2khz or 25kHz.

U. Control and User Interface

3. The fixture shall be USITT DMX 512A-compatible via in and thru 5-pin XLR connectors.
4. The fixture shall be compatible with the ANSI RDM E1.20 standard.
  - a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console.
  - b. Temperature sensors within the luminaire shall be viewable in real time via RDM and UI.
  - c. Fixtures not offering RDM compatibility, feature set access, or temperature monitoring via RDM shall not be compatible.
5. The fixture shall be equipped with multi-line LCD display for easy-to-read status reports and configuration changes.
  - a. Display must have a feature to battery power the menu when the fixture is unplugged to allow fixture settings to be adjusted, including DMX address.
6. The fixture shall be equipped with a five-button user interface.
7. The fixture shall offer two DMX control profiles.
  - a. Direct DMX control profile shall have 24 channel control.
  - b. Simple DMX control profile shall have 20 channel control.

V. Initialization

3. The fixture shall be fitted with high resolution absolute position encoders on the pan and tilt axes such that initialization on power up or reset can be accomplished with zero or minimal movement of these axis.
4. Fixtures not offering absolute position sensors and that are required to move the pan and tilt axis home to fixed sensor positions or end stops in order to initialize shall not be acceptable.
5. The time to fully initialize the fixture from power on or reset shall be no more than 35 seconds.

1.17 COLOR MIXING OR WHITE-LIGHT LIGHT EMITTING DIODE PROFILE FIXTURE

K. General

3. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a Source Four LED Series 2 as manufactured by Electronic Theatre Controls, Inc. or approved equal.
4. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
5. The fixture shall be UL 1573 listed for stage and studio use
6. The fixture shall comply with the USITT DMX-512A standard

L. Physical

3. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits, finished in black.
4. The following shall be provided:
  - a. Lens secured with silicone shock mounts
  - b. Shutter assembly shall allow for +/-25° rotation
  - c. 20 gauge stainless steel shutters
  - d. Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement
  - e. Sturdy integral die cast gel frame holders with two accessory slots, and a top-mounted, quick release gel frame retainer
  - f. Rugged steel yoke with two mounting positions allowing 300°+ rotation of the fixture within the yoke
  - g. Positive locking, hand operated yoke clutch
  - h. Slot with sliding cover for motorized pattern devices or optional iris
5. The housing shall have a rugged black powder coat finish
  - a. White or silver/gray powder coat finishes shall be available as color options
  - b. Other powder coat color options shall be available on request
6. Power supply, cooling and electronics shall be integral to each unit.
7. The unit shall ship with:
  - a. Theatrical-style hanging yoke as standard
  - b. 5' Neutrik PowerCon™ to Edison power cable as standard
  - c. Gate diffuser
  - d. A-size pattern holder
8. Available options shall include but not be limited to:
  - a. Bare-end, Stage-Pin or Twist-lock type-equipped power leads
  - b. PowerCon to PowerCon cables for fixture power linking
  - c. Smooth Wash Diffuser for overlapping beams of light from multiple fixtures

M. Optical

3. The light beam should have a 2-to-1 center-to-edge drop-off ratio
4. The unit shall provide, but not be limited to:
  - a. Low gate and beam temperature
  - b. Sharp imaging through a three-plane shutter design
5. The unit shall provide, but not be limited to:

- a. 5, 10, 14, 19, 26, 36, 50, 70 and 90 degree field angles
  - b. High-quality pattern imaging
  - c. Sharp shutter cuts without halation
  - d. Shutter warping and burnout in normal use shall be unacceptable
  - e. Adjustable hard and soft beam edges
6. 19, 26, 36, and 50 degree units shall have optional lens tubes available for precision, high-contrast imaging.

N. Environmental and Agency Compliance

- 3. The fixture shall be ETL and cETL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
- 4. The fixture shall be ETL LISTED to the UL1573 standard for stage and studio use
- 5. The fixture shall be rated for IP-20 dry location use.

O. Thermal

- 3. Fixture shall be equipped with a cooling fan.
  - a. Fan speed control via a DMX channel shall be possible
  - b. Fan speed software shall permit the fixture to override DMX fan speed setting to prevent heat damage to the fixture
- 4. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 54,000 hours of use (Lustr) and 20,000 hours (Tungsten HD and Daylight HD)
  - a. Thermal management shall include multiple temperature sensors within the housing to include:
    - 1) LED array circuit board temperatures
    - 2) Temperature sensors placed on each individual LED color circuit
    - 3) Fixture ambient
    - 4) CPU
  - b. Fixture user shall permit monitoring of temperature sensors via a legible LCD multi-line backlit display
  - c. Fixtures that do not provide active thermal monitoring of LED circuits and other temperature readings shall not be acceptable
- 5. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

P. Electrical

- 3. The fixture shall be equipped with a 100V to 240V 50/60Hz internal power supply
- 4. The fixture shall support power in and thru operation

- a. Power in shall be via Neutrik® PowerCon™ input connector
  - b. Power thru shall be via Neutrik® PowerCon™ output connector
  - c. Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
- 5. The fixture requires power from a non-dim source
  - 6. Power supply outputs shall have self-resetting current-limiting protection
  - 7. Power supply shall have power factor correction

Q. LED Emitters

- 3. The fixture shall contain a minimum of four different LED colors to provide color characteristics as described in the Color Section below.
- 4. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
  - a. Fixture shall utilize Luxeon® Rebel™ and/or Osram OSLON Square LED emitters
- 5. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
- 6. All LED fixtures (100% of each lot) shall undergo a minimum three-hour burn-in test during manufacturing.
- 7. LED system shall comply with all relevant patents
- 8. Fixtures shall have adjustable PWM frequency up to 25,000hz to avoid flicker on camera

R. Longevity

- 3. The Lustr fixture shall be provided with an LM-84 test report from a nationally recognized test lab
  - a. LM-84 results shall be no less than 54,000 hours L70 rating
- 4. All fixtures shall be provided with the minimum warranty:
  - a. 5 years full fixture coverage
  - b. 10 years LED coverage

S. Calibration

- 3. Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
  - a. Calibration data shall be stored on the LED array as a permanent part of on-board operating system

- b. All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
- c. Fixtures not offering LED calibration shall not be acceptable

T. Color

- 3. The fixture shall utilize a minimum of 60 LED emitters
- 4. The fixture shall be available in specialized LED arrays as outlined below:
  - a. Source Four LED Series 2 Lustr
    - 1) Red, Amber, Green, Cyan, Blue, Indigo and Lime LEDs in an array designed for broad spectrum color, light tints, and variable whites. This array shall be the Lustr array as manufactured by Electronic Theatre Controls, or approved equal
      - a) Measured brightness of the Lustr array shall be greater than 6,500 field lumens
  - b. Source Four LED Series 2 Tungsten HD
    - 1) Mint, red, orange, blue, and indigo in an array designed to provide a variable white-light adjustable from 2700K to 6500K. (Designed for highest CRI and output between 2700K and 4500K) This array shall be the Tungsten HD array as manufactured by Electronic Theatre Controls, or approved equal
      - a) Measured brightness of the Tungsten HD array shall be greater than 10,000 field lumens
  - c. Source Four LED Series 2 Daylight HD
    - 1) Mint, red, blue, and indigo in an array designed to provide a variable white-light adjustable from 2700K to 6500K. (Designed for highest CRI and output between 4000K and 6500K) This array shall be the Daylight HD array as manufactured by Electronic Theatre Controls, or approved equal
      - a) Measured brightness of the Daylight HD array shall be greater than 10,000 field lumens

U. Dimming

- 3. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
- 4. At least four different dimming curve options shall be accessible at the fixture's User Interface
  - a. Incandescent
  - b. Standard
  - c. Linear
  - d. Quick
- 5. Dimming curves shall be optimized for smooth dimming over longer timed fades.

6. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
  7. LED control shall be compatible with broadcast equipment in the following ways:
    - a. PWM control of LED levels shall be imperceptible to video cameras and related equipment
    - b. PWM rates shall be adjustable by the user at the fixture if necessary to avoid any visible interference to video cameras and related equipment
- V. Control and User interface
3. The fixture shall be USITT DMX 512A-compatible via In and Thru 5-pin XLR connectors
  4. The fixture shall be compatible with the ANSI RDM E1.20 standard
    - a. All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
    - b. Temperature sensors within the luminaire shall be viewable in real time via RDM
    - c. Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
  5. The fixture shall be equipped with multi-line LCD display for easy-to-read status reports and configuration changes
  6. The fixture shall be equipped with a six-button user-interface
  7. The fixture shall offer multiple DMX input profile options to include:
    - a. RGB - control of all individual LED colors via a three-channel profile
      - 1) Red, Green, Blue
    - b. HSI – control of all individual LED colors via a three-channel profile
      - 1) Hue, Saturation, Intensity
    - c. HSIC – control of all LED colors via a four-channel profile
      - 1) Hue, Saturation, Intensity and Color Point
        - a) Color point provides variable color temperature settings
    - d. Direct – control of each individual color channel via an independent channel
    - e. Studio – Control of the fixture in a white-light 3 channel profile
      - 1) Intensity, Color Temperature, +/- Green (Tint)
        - a) Without DMX the fixture can master other Source Four LEDs and Desire fixtures that are connected via 5 pin XLR DMX cables
    - f. A variable-rate strobe channel shall be provided
  8. The fixture shall offer three output settings

- a. Boost mode - powers LEDs at maximum intensity and provides no compensation against LED 'droop' or intensity loss
  - b. Regulated mode – slightly restricts maximum LED intensity levels to compensate against LED droop
  - c. Protected mode – further restricts maximum LED intensity levels to compensate against LED droop and offer color consistency at highest permissible ambient temperatures (40C)
  - d. Fixtures that do not provide regulated and protected operation modes are not acceptable
- 9. The fixture shall offer additional user-definable options to including but not limited to:
  - a. Display time out options
  - b. Loss of data behavior options
  - c. White point settings
  - d. Red-shift option for tungsten dimming emulation
- 10. The fixture shall offer five Quick Set-Ups to allow user to rapidly select different combinations of the numerous user options based on the desired usage situation, to include:
  - a. General – for most situations
  - b. Stage – when emulating incandescent fixtures is desired
  - c. High Impact – when maximum output and effect is desired
  - d. XT Arch – when color consistency and architectural characteristics are desired.
  - e. Studio - when DMX or stand-alone of white light output is required with intensity, color temperature and color tint control parameters
- 11. The fixture shall offer stand-alone functionality eliminating the need for a console
  - a. Fixture shall ship with 24 preset colors accessible as a stand-alone feature
  - b. Fixture shall ship with 12 sequences accessible as a stand-alone feature
  - c. Each color and sequence can be modified by the end user
  - d. Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
    - 1) Up to 32 fixtures may be linked
  - e. Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming
  - f. Fixtures without stand-alone operation features described above shall not be acceptable.
- 12. The fixture shall be capable of copying all performance settings to other fixtures of the same type via a 5 pin XLR DMX cable

○ COLOR MIXING LIGHT EMITTING DIODE WASH FIXTURE

W. General

3. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a Desire D40 or D40 Studio as manufactured by Electronics Theatre Controls, Inc. or approved equal.
4. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
5. The fixture shall be UL 1573 listed for stage and studio use
6. The fixture shall comply with the USITT DMX-512 A standard
7. The fixture shall be provided with the minimum warranty of 5 years full fixture coverage and 10 years LED array coverage
8. All LED emitters must have a L70 rating of no less than 50,000 hours
  - Substitutes must provide evidence of minimum L70 rating of no less than 50,000 hours via a LM-80 report on all emitters
    - LM-80 report must be provided with a LM-79 report and an in situ temperature measurement test verifying the conditions of the fixture meet the conditions of the LM-80 report
    - All tests and reports must be completed by a Nationally Recognized Testing Laboratory
    - All tests must be conducted to IES standards

X. Physical

3. The fixture shall be contained in a rugged all-metal die-cast housing, free of burrs and pits.
4. The housing shall have a rugged black powdercoat finish
  - White or silver/gray powdercoat finishes shall be available as color options
  - Other powdercoat color options shall be available on request
5. Power supply, cooling and electronics shall be integral to each unit.
6. Fixture housing shall provide two easy-access slots for secondary lenses and other accessories
  - Slots shall be equipped with locking retaining clip
7. The unit shall ship with:
  - Theatrical-style hanging yoke as standard
  - 5' power lead with Edison connector as standard
8. Available options shall include but not be limited to:
  - Yoke with floor stand conversion feature

- Bare-end, Stage-Pin or Twist-lock type-equipped power leads
  - PowerCon to PowerCon cables for fixture power linking
  - Multiple secondary lens options to include multiple angles in the following patterns:
    - Linear
    - Round
    - Oblong
9. Light output shall be via a round aperture
- Aperture and accessory slots shall accommodate standard 7.5" accessories such as used in other similar-sized fixtures
  - Accessories available as options shall include but not be limited to:
    - Gel/diffusion frames
    - Top hats
    - Barndoors
    - Egg crate louvers
    - Concentric ring louvers
    - Multiple secondary lensing options

Y. ENVIRONMENTAL AND AGENCY COMPLIANCE

- 3. The fixture shall be UL and cUL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
- 4. The fixture shall be UL LISTED to the UL1573 standard for stage and studio use
- 5. The fixture shall be rated for IP-20 dry location use.

Z. THERMAL

- 3. Fixture shall be totally convection cooled, requiring no cooling fan. Fixtures which require an on-board cooling fan shall not be acceptable unless pre-approved
- 4. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 50,000 hours of use
  - Thermal management shall include multiple temperature sensors within the housing to include:
    - LED array circuit board temperatures
    - Temperature sensors placed on each individual LED color circuit
    - Fixture ambient
    - CPU
  - Fixture user shall permit monitoring of temperature sensors via a legible LCD multi-line backlit display
  - Fixtures that do not provide active thermal monitoring of LED circuits and other temperature readings shall not be acceptable

5. The fixture shall operate in an ambient temperature range of -20°C (-4°F) minimum, to 40° C (104°F) maximum ambient temperature.

AA. ELECTRICAL

3. The fixture shall be equipped with 100V to 240V 50/60 Hz internal power supply
4. The fixture shall support power in and thru operation
  - Power in shall be via Neutrik® PowerCon™ input connector
  - Power thru shall be via Neutrik® PowerCon™ output connector
  - Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
5. The fixture requires power from non-dim source
6. Power supply outputs shall have self-resetting current limiting protection
7. Power supply shall have power factor correction

BB. LED Emitters

3. The fixture shall contain a minimum of 5 different LED colors to provide color characteristics as described in Section G below.
4. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
  - Fixture shall utilize Luxeon® Rebel™ LED emitters
5. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
6. LED emitters should be rated for nominal 50,000 hour LED life to 70% intensity
7. All LED fixtures (100% of each lot) shall undergo a minimum eight-hour burn-in test during manufacturing.
8. LED system shall comply with all relevant patents

CC. CALIBRATION

3. Fixture shall be calibrated at factory for achieve consistent color and intensity output between fixtures built at different times and/or from different LED lots or bins
  - Calibration data shall be stored on the LED array as a permanent part of on-board operating system
  - All arrays, including replacement arrays shall be calibrated to the same standard to insure consistency
  - Fixtures not offering LED calibration shall not be acceptable

DD. COLOR

3. The fixture shall utilize an minimum of 40 LED emitters
4. The fixture shall be available in specialized LED arrays as outlined below:
  - Desire D40
    - Red, Amber, Green, Cyan, Blue, Indigo and White LEDs in an array designed for broad spectrum color, light tints, and variable whites. This array shall be the Lustr+ array as manufactured by Electronic Theatre Controls, or approved equal
      - Measured brightness of the Lustr+ array shall be greater than 2900 field lumens
    - Red, Orange, Amber, Green, Cyan, Blue and Indigo LEDs in an array designed for broad spectrum deep colors. This array shall be the Vivid array as manufactured by Electronic Theatre Controls, or approved equal
      - Measured brightness of the Vivid array shall be greater than 2500 field lumens
    - Red, Orange, Amber, Green and Indigo LEDs in an array designed for extra-high brightness output in red/warm end of the spectrum. This shall be the Fire array as manufactured by Electronic Theatre Controls, or approved equal
      - Measured brightness of the Fire array shall be greater than 2500 field lumens
    - Red, Orange, Green, Cyan, Blue and Indigo LEDs in an array designed for extra-high brightness output in the blue/cool end of the spectrum. This shall be the Ice array as manufactured by Electronic Theatre Controls, or approved equal
      - Measured brightness of the Ice array shall be greater than 1800 field lumens
  - Desire D40 Studio
    - Warm White, Cool White, Red, Green, Blue and Indigo LEDs in an array designed for high-brightness variable color temperature white light output. This shall be the Studio HD array as manufactured by Electronic Theatre Controls, or approved equal
      - Measure brightness of the Studio HD array shall be greater than 3100 field lumens
    - All Warm White LEDs in an array designed for non-variable single color high-output, warm white light. This shall be the Studio Tungsten array as manufactured by Electronic Theatre Controls, or approved equal
      - Measure brightness of the Studio tungsten array shall be greater than (TBD) field lumens
    - All Cool White LEDs in an array designed for non-variable single color high-output, cool white light. This shall be the Studio Daylight array as manufactured by Electronic Theatre Controls, or approved equal
      - Measure brightness of the Studio Daylight array shall be greater than (TBD) field lumens
  -

EE. DIMMING

3. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
4. At least four different dimming curve options shall be accessible at the fixture's User Interface
  - Incandescent
  - Standard
  - Linear
  - Quick
5. Dimming curves shall be optimized for smooth dimming over longer timed fades.
6. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
7. LED control shall be compatible with broadcast equipment in the following ways:
  - PWM control of LED levels shall be imperceptible to video cameras and related equipment
  - PWM rates shall be adjustable by the user at the fixture if necessary to avoid any visible interference to video cameras and related equipment

FF. CONTROL AND USER INTERFACE

3. The fixture shall be USITT DMX 512A-compatible via **In** and **Thru** 5-pin XLR connectors
4. The fixture shall be compatible with the ANSI RDM E1.20 standard
  - All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console
  - Temperature sensors within the luminaire shall be viewable in real time via RDM
  - Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
5. The fixture shall be equipped with multi-line LCD display for easy-to-read status reports and configuration changes
6. The fixture shall be equipped with a six-button user-interface
7. The fixture shall offer multiple DMX input profile options to include:
  - RGB - control of all individual LED colors via a three-channel profile
    - Red, Green, Blue
  - HSI – control of all individual LED colors via a three-channel profile
    - Hue, Saturation, Intensity
  - HSIC – control of all LED colors via a four-channel profile
    - Hue, Saturation, Intensity and Color Point

- Color point provides variable color temperature settings
  - Direct – control of each individual color channel via an independent channel
  - A variable-rate strobe channel shall be provided
8. The fixture shall offer three output settings
- Boost mode - powers LEDs at maximum intensity and provides no compensation against LED 'droop' or intensity loss
  - Regulated mode – slightly restricts maximum LED intensity levels to compensate against LED droop
  - Protected mode – further restricts maximum LED intensity levels to compensate against LED droop and offer color consistency at highest permissible ambient temperatures (40C)
  - Fixtures that do not provide regulated and protected operation modes are not acceptable
9. The fixture shall offer additional user-definable options to including but not limited to:
- Display time out options
  - Loss of data behavior options
  - White point settings
  - Red-shift option for tungsten dimming emulation
10. The fixture shall offer five Quick Set-Ups to allow user to rapidly select different combinations of the numerous user options based on the desired usage situation, to include:
- General – for most situations
  - Stage – when emulating incandescent fixtures is desired
  - High Impact – when maximum output and effect is desired
  - XT Arch – when color consistency and architectural characteristics are desired.
  - Studio - when DMX or stand-alone of white light output is required with intensity, color temperature and color tint control parameters
11. The fixture shall offer stand-alone functionality eliminating the need for a console
- Fixture shall ship with 24 preset colors accessible as a stand-alone feature
  - Fixture shall ship with 12 Sequences accessible as a stand-alone feature
  - Each color and sequence can be modified by the end user
  - Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
    - Up to 32 fixtures may be linked
  - Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming

- Fixtures without stand-alone operation features described in a, b, c, d, and e shall not be acceptable.

## 1.18 ELLIPSOIDAL SPOTLIGHTS

### K. General

3. The instrument shall be a Source Four ellipsoidal spotlight as manufactured by Electronic Theatre Controls, Inc., or approved equal.

### L. Physical

3. The unit shall be constructed of rugged, die cast aluminum, free of burrs and pits, finished in black, high temperature epoxy paint. Tools shall not be required for either lamp alignment or cleaning the reflector or lens
4. The following shall be provided:
  - a. Integral cable clamp for power leads
  - b. Positive locking of lamp focus and independent lamp alignment controls
  - c. High impact, thermally insulated knobs and shutter handles
  - d. Reflector secured with shock mounts
  - e. Lens secured with silicone shock mounts
  - f. Shutter assembly shall allow for +/-25° rotation
  - g. 20 gauge stainless steel shutters
  - h. Insulated rear handle
  - i. Interchangeable lens tubes for different field angles with Teflon guides for smooth tube movement
  - j. Sturdy integral die cast gel frame holders with two accessory slots, and a top mounted, quick release gel frame retainer
  - k. Rugged 3/16" x 1-1/4" steel yoke with two mounting positions allowing 300°+ rotation of the fixture within the yoke
  - l. Positive locking, hand operated yoke clutch
  - m. Slot with sliding cover for motorized pattern devices or optional iris

### M. Optical

3. The optical train shall combine a compact filament lamp with a precision molded borosilicate, ellipsoidal reflector and aspheric lens to produce an optimum cosine field.
4. The unit shall provide, but not be limited to:
  - a. Molded borosilicate reflector with multiple dichroic layers
  - b. 95% of visible light shall be reflected while 90% of infrared light as heat shall be transmitted through the reflector
  - c. Low gate and beam temperature

- d. Sharp imaging through a three plane shutter design
- e. Projector-quality, high contrast aspheric lens, with an anti-reflective coating to increase transmission

N. Performance

- 3. The unit shall be precision engineered to use an HPL lamp to deliver an even, intense field with cosine distribution.
- 4. The unit shall provide, but not be limited to:
  - a. 5, 10, 14, 19, 26, 36, 50, 70 and 90 degree field angles
  - b. High-quality pattern imaging
  - c. Sharp shutter cuts without halation
  - d. Shutter warping and burnout in normal use shall be unacceptable
  - e. Adjustable hard and soft beam edges
- 5. The unit shall be capable of utilizing ETC Dimmer Doubling technology
- 6. The unit shall be UL and cUL listed and so labeled.
- 7. 19, 26, 36, and 50 degree units shall have optional lens tubes available for precision, high-contrast imaging.

O. Lamp

- 3. The high efficiency lamp shall be an HPL lamp, which shall consist of a compact tungsten filament contained in a krypton-filled quartz envelope. The lamp shall mount axially within the reflector. The lamp base shall have an integral die cast aluminum heat sink that reduces seal temperature and ensures proper lamp alignment. The lamp socket shall be ATP 220 nickel gold plated.

xvi. Enhanced Definition Lens Tubes

- 170. The product shall be an optional fixed focus lens tube with a field angle of (19° - 26° - 36° - 50°) for use with a Source Four ERS fixture body. When used as a template or gobo projector, the product shall provide enhanced image acuity,

heightened contrast and minimum distortion when compared to any other fixed focus ERS fixtures.

171. The product shall result in no loss of field lumens when compared to standard fixed focus fixtures.
172. The product shall be retrofit-able into any new or existing Source Four ERS fixture body. The product shall be available as an accessory and not require the purchase of an entire fixture.
173. The product shall be labeled in such a way as to easily distinguish it from standard lens tubes. The product shall not be labeled or marked in such a way as to be garish or distracting when placed in a system with other fixtures.
174. The product shall be available in black standard with silver, white and custom colors as options.

○ COLOR MIXING LIGHT EMITTING DIODE CYCLORAMA FIXTURE

P. General

3. The fixture shall be a color-mixing high-intensity LED illuminator with DMX control of intensity and color. The fixture shall be a ColorSource® CYC as manufactured by Electronic Theatre Controls, Inc. or approved equal.
4. All LED fixtures shall be provided by a single manufacturer to ensure compatibility
5. The fixture shall be UL 1573 listed for stage and studio use
6. The fixture shall comply with the USITT DMX512-A standard

Q. Physical

3. The fixture shall be contained in a rugged all-metal die-cast housing, free of burrs and pits.
4. The housing shall have a rugged black powder coat finish
  - White or silver/gray powder coat finishes shall be available as color options
  - Other powder coat color options shall be available on request
5. Power supply and electronics shall be integral to each unit.
6. Fixture housing shall provide built in spill control
7. Fixture shall operate directly on the ground or by hanging via yoke
8. The unit shall ship with:
  - Theatrical-style hanging yoke as standard
  - 5' power lead with Neutrik® PowerCON™ to Edison connector as standard
9. Available options shall include but not be limited to:
  - DMX input via RJ45 connector
10. Light output shall be produce an asymmetrical beam
  - Lensing shall be designed to provide smooth coverage both horizontally and vertically for seamless blending from fixture to fixture
  - With a minimum setback from the cyclorama of 2', the fixtures shall be able to achieve a 2-to-1 spacing ration and maintain smooth coverage

R. ENVIRONMENTAL AND AGENCY COMPLIANCE

3. The fixture shall be UL and cUL LISTED and/or CE rated, and shall be so labeled when delivered to the job site.
4. The fixture shall be UL LISTED to the UL1573 standard for stage and studio use

5. The fixture shall be rated for IP-20 dry location use.

S. THERMAL

3. The fixture shall be natural convection cooled and shall not use a fan
4. The fixture shall utilize advanced thermal management systems to maintain LED life to an average of 70% intensity after 50,000 hours of use
  - Thermal management shall include multiple temperature sensors within the housing to include:
    - The LED array
    - The control board
5. The fixture shall operate in an ambient temperature range of 0°C (32°F) minimum, to 40° C (104°F) maximum ambient temperature.

T. ELECTRICAL

3. The fixture shall be equipped with 100V to 240V 50/60 Hz internal power supply
4. The fixture shall support power in and thru operation
  - Power in shall be via Neutrik® PowerCON™ input connector
  - Power thru shall be via Neutrik ® PowerCON™ output connector
  - Fixture power wiring and accessory power cables shall be rated to support linking of multiple fixtures up to the capacity of a 15A breaker
5. The fixture requires power from non-dim source
6. Power supply shall have power factor correction

U. LED Emitters

3. The fixture shall contain 5 different LED colors to provide color characteristics as described in Section H below.
4. All LEDs used in the fixture shall be high brightness and proven quality from established and reputable LED manufacturers.
  - Fixture shall utilize Luxeon® C™ LED emitters
5. Manufacturer of LED emitters shall utilize an advanced production LED binning process to maintain color consistency.
6. LED emitters should be rated for nominal 50,000 hour LED life to 70% intensity
7. LED system shall comply with all relevant patents
8. Fixtures shall have a flicker free mode that will set the LED refresh rate to 25,000 Hz for flicker free operation on camera

V. Warranty

3. The fixture shall be provided with the minimum warranty:

- 5 years full fixture coverage
- 10 years LED coverage

W. CALIBRATION

3. Fixture shall be calibrated at factory for achieve consistent color between fixtures built at different times and/or from different LED lots or bins
- Calibration data shall be stored in the fixture as a permanent part of on-board operating system
  - All arrays, including replacement arrays shall be calibrated to the same standard to ensure consistency
  - Fixtures not offering LED calibration shall not be acceptable
4. Fixture shall have droop compensation to overcome thermal droop in the LEDs to maintain output levels and color point.

X. COLOR

3. The fixture shall utilize a minimum of 42 LED emitters
- These emitters shall be made up of Red, Green, Blue, Indigo and Lime

Y. DIMMING

3. The LED system shall use 15-bit nonlinear scaling techniques for high-resolution dimming.
4. The dimming curve shall be optimized for smooth dimming over longer timed fades.
5. The LED system shall be digitally driven using high-speed pulse width modulation (PWM)
6. LED control shall be compatible with broadcast equipment in the following ways:
- PWM control of LED levels shall be imperceptible to video cameras and related equipment
  - PWM rates shall be adjustable by the user via RDM to avoid any visible interference to video cameras and related equipment

Z. CONTROL AND USER INTERFACE

3. The fixture shall be USITT DMX512-A compatible via **In** and **Thru** 5-pin XLR connectors or RJ45 connectors
4. The fixture shall be compatible with the ANSI RDM E1.20 standard
- All fixture functions shall accessible via RDM protocol for modification from suitably equipped control console

- Temperature sensors within the luminaire shall be viewable in real time via RDM
  - Fixtures not offering RDM compatibility, feature set access or temperature monitoring via RDM shall not be compatible
5. The fixture shall be equipped with a 7-segment display for easy-to-read status and control
6. The fixture shall be equipped with a three-button user-interface
7. The fixture shall offer multiple control modes including but not limited to:
- RGB
  - 5 channel (IRGBS)
  - Direct
  - Single channel
8. The fixture shall operate in Regulated mode for droop compensation
9. The fixture shall offer stand-alone functionality eliminating the need for a console
- Fixture shall ship with 12 preset colors accessible as a stand-alone feature
  - Fixture shall ship with 5 Sequences accessible as a stand-alone feature
  - Each preset can be modified by the end user
  - Fixtures can be linked together with standard DMX cables and controlled from designated master fixture
    - Up to 32 fixtures may be linked
  - Fixtures in a stand-alone state shall restore to the settings present prior to power cycling, eliminating the need for reprogramming
  - Fixtures without stand-alone operation features described in a, b, c, d, and e shall not be acceptable.
  -

C. %.

### PART 3. EXECUTION

#### 3.01 CONDUIT AND WIRING

##### A. General:

8. Carefully label clearly and permanently then remove exiting branch circuits. Branch circuits are two wire only. Common neutrals not permitted
- B. Terminate wires matching dimmer numbers to the original dimmers with pressure type connections.
- C. Run wiring to new devices as specified, and connect into these devices in such a manner that the circuits are numbered within as shown in the attached schedule, and/or so that the circuits number from Stage Left to Stage Right.
- D. Wire new branch circuits with neutrals of size equal to the hot line. Branch circuits two wire only. Common neutrals not permitted
- E. Terminate wires with pressure type connections and label clearly and permanently.

- F. Run wiring to devices as specified, and connect into these devices in such a manner that the circuits are numbered within as shown in the attached schedule, and/or so that the circuits number from Stage Left to Stage Right, Downstage to Upstage, or from Top to Bottom of the respective device.
- G. Where field verification of low voltage cables runs indicate their performance may be impacted by the total length of the cable run, Electrical Contractor and Theatrical Systems Integrator shall coordinate to find a suitable alternative, such as substitution of cable or model number of product, which does not impact the specified functionality of the system.

Conduit Runs:

Conceal conduit runs, over ceilings, etc.

Permanently set items such as junction boxes, and plug boxes are to be attached directly to conduit.

The electrical contractor shall be responsible for field measurements and coordinating physical size of all equipment with the Electrical Engineering requirements of the spaces into which they are to be installed.

The electrical contractor shall install all lighting control and dimming equipment in accordance with manufacturer's approved shop drawings.

All branch load circuits shall be live tested before connecting the loads to the dimmer system load terminals.

RESPONSIBILITY MATRIX

3.02 Responsibility Matrix

- A. The Matrix spreadsheet in TL drawings outlines the responsibilities associated with the items in this specification. Box Numbers correlate to devices shall be found on TL Plans & Riser.

END OF SECTION 26 55 61

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## GENERAL REQUIREMENTS BY OWNER

### Telecommunications Equipment Rooms - General:

1. All ER's and TR's shall have access doors from public spaces.
2. All telecommunications room floors are to be clean and sealed before data racks, patch panels, or other equipment is installed.
3. Room layout and equipment layout within racks shall be approved by Owner before any equipment is installed.
4. All ER's and TR's shall have **24/7/365 temperature and humidity control**. Typically this shall be a separate unit from building HVAC systems. Main data wiring center will typically have a 7,000 watt heat load from the data switch gear. This heat load needs to be considered in unit sizing. ER and TR HVAC units shall be capable of operation below zero degrees Fahrenheit external temperature.
5. No lines that do or may carry any liquid shall be installed in or pass through ER's and TR's.
6. No electrical switch gear shall be installed with any ER or TR.
7. ER's and TR's shall not be shared spaced used for any other purpose.
8. There shall be no less than 60 inches clearance between the back of any row of racks and the nearest wall or row of racks. There shall be no less than 42 inches clearance between the front of any row of racks and the nearest wall. There shall be no less than 42 inches clearance at the end of any row of racks on the end opposite the starting wall of the row. There shall be no less than 6 inches clearance between the start of any row of racks and the nearest wall. (this includes wire management)

### Telecommunications and Networking Requirements -General:

1. There shall be a Cat6A outlet anywhere a wall mounted TV or video display is shown.
2. There shall be a CAT6 wall mounted telephone outlet at ADA height in each classroom, conference room, and lab specifically for an ENS (Emergency Notification System) phone. This is stand alone and separate from any general use telephone(s) in the room. Where appropriate these shall be installed near the teaching station or at the front of the room.
3. There shall be a wireless access point connection in the ceiling per 25 students in a given area such as classrooms, labs, etc. All wireless access point locations shall have one CAT6A connection. **In areas with high ceilings wireless access points shall be installed no higher than twelve feet above finished floor.** Wireless access point layout must be approved by Owner before installation.
4. There shall be a wall mounted telephone jack installed at ADA height near the doorway in all mechanical rooms, electrical rooms, storage rooms, etc.

5. All jacks called out for Data shall be Electrical Ivory and all jacks called out for Voice shall be Blue. Face plates shall also be Electrical Ivory unless contract specifies face plate color to be the same as electrical face plate color.
6. **Every space including hallways, restrooms, closets, stairwells, etc shall have a unique room number identifier.** Final room numbers shall be confirmed with the Owner before construction documents are issued. **Once construction begins room numbers shall not change.**
7. Please clarify any questions with Owner prior to bidding, construction, or installation.
8. Contractor shall maintain and provide to ISU a Microsoft Excel spreadsheet in electronic format of all connections installed with the following fields filled out. **NO DATA PORTS WILL BE ACTIVATED UNTIL THIS SHEET IS PROVIDED FULLY FILLED OUT TO OWNER:**
  - a. Room Number
  - b. Jack Label
  - c. Wire label
  - d. IDF Room Number
  - e. Rack Label for patch panel
  - f. Patch Panel label
  - g. Patch panel port
  - h. Cable Length

**Telecommunications and Networking Room -Architectural:**

1. The (ER) minimum room size shall be 10' deep and 12' wide for the main equipment room.
2. The minimum size for a Telecommunications Room(s) (TR) shall be 10' deep and 8' wide.
3. The minimum ceiling height shall be 9 feet above finished floor (AFF).
4. To permit maximum flexibility and accessibility of cabling pathways, false ceilings are not permitted.
5. Walls SHALL extend to structural ceiling.
6. Ceiling, floor, and wall finish that minimizes dust shall be used.
7. Design ER/TRs to have fully opening (to 180 degrees recommended), lockable doors that are minimally 42 inch wide and 80 inches tall.
8. Door sills are not allowed because they impede the movement of equipment.
9. Removable center posts are permitted, if required.
10. Install doors to be removable.
11. Dust and Static Electricity; Avoid dust and static electricity by:
  - a. Installing tile instead of carpet.
  - b. Treating floors, walls, and ceiling to minimize dust.

12. Doors SHALL open outward.
13. Doors SHALL have locks with campus master "FM5" installed.

### **Telecommunications and Networking Rooms - Environmental Control:**

#### **Provide HVAC that will:**

1. Maintain continuous and dedicated environmental control (**24 hours per day, 365 days per year.**)
2. If emergency power is available, consider connecting it to the HVAC system that serves the ER/TR.
3. Maintain positive pressure have have a minimum of one air change per hour in the ER/TR.
4. Dissipate the heat generated by active devices.
5. Provide 300ft cubed of 54 degrees conditioned air per 20 ampere (A) dedicated electrical outlet.
6. The temperature range should be 64 degrees to 75 degrees.
7. The humidity range should be 30% to 55% relative humidity.
8. Keep changes in temperature and humidity to a minimum.
9. ERs/TRs should be calculated using 7500 BTU/HR from communications equipment.

### **Fire Protection**

1. If sprinkler heads are provided, install wire cages to prevent accidental operation.
2. For wet pipe systems, drainage troughs are required to protect equipment from any leakage that may occur.
3. To prevent water damage, consider using "dry pipe" sprinkler systems.

### **Lighting**

1. Provide a minimum equivalent of 500 lux (50 footcandles) measured 3 feet AFF.
2. Coordinate closely with the rack/cabinet placements.
3. Locate light fixtures a minimum of 9 feet AFF.
4. Light fixtures SHALL be positioned to provide adequate light to front and rear of racks as well as backboards.
5. Emergency lighting is required. Place emergency lighting to ensure that the loss of power to normal lights will not hamper an emergency exit from the TR.
6. ER/TR shall not have motion and/or timer based lighting.ER/

## **Other Uses**

1. ER/TRs should be dedicated to the telecommunications function and related support facilities. Equipment not related to the support of the ER/TRs (e.g. piping, duct work, and distribution of building power) should not be located in, or pass through, the ER/TR.
2. The ER/TR shall not be shared with building users or custodial services.

## **Power**

1. On the wall at the end of each row of relay racks install two (2) 5-20 110vac outlets.
2. On the wall at the end of each row of relay racks install two (2) L6-30 208vac outlets per 224 data/voice outlets terminated in the relay racks. L6-30 208vac outlets are to be installed in pairs. One of each pair is to be on building commercial power. And one of each pair is to be on the building emergency generator power.
3. Make sure there are a minimum of two (2) quad 5-20 110vac outlets evenly spaced on each of the four walls.
4. All outlets in telecommunications rooms are to be on building emergency generator power except as noted in item #2 above.
5. All outlets must have labels indicating the circuit / breaker panel and if they are commercial or generator feed.
6. Consider providing emergency power to the ER/TR with automatic switchover capability.
7. Distribution panels that serve telecommunications equipment should be separate from those that serve lighting fixtures.
8. At least one electrical outlet shall be on normal power, and one electrical outlet shall be on emergency power.
9. Outlets requirements on backboards as well as racks/cabinets as shown on the enlarged floorplans.

## **Data Communications Equipment**

1. Owner shall provide network electronics – Network Switches and Access Points.
2. Ceiling mount Access Point identification and installation.
  - a. All locations shall have labeling consistent with wall plate labeling specified in 27.11.16.0.

- b. Optimal mounting height is 8 to 12 feet in height from the floor. Exceptions need to be approved by the owner.
  - c. Access points that mount to ceiling grid / drop ceilings shall have the label placed on the grid at the location of the terminated cable. 10' service loops only apply to these types.
  - d. Access points that mount to hard ceilings will have a duplex box mounted flush with the ceiling and the network cable terminated and through the box. No wall plate is required. No extra service loop required.
  - e. Access points that mount in open concept ceilings will have an appropriate conduit and box to mount the Access point to. Should the ceiling exceed 12' in height a conduit with a quad box shall be mounted and extended down from the structure to the desired height. The Box and Conduit can be painted as desired to match the decore. The final height of the should be even or slightly below any other hanging objects such as lights, ventilation etc. to offer optimal wireless coverage.
  - f. All ceiling access points and necessary brackets will be provided by the owner and the contractor will hang the access points. Installation shall be in accordance with the designated location and methods required by the specific mounting type. Installation shall not occur until after the cable is tested / certified and while lifts and ladders are still available to mount the equipment.
  - g. The contractor will add the cable labels to the face of each access point after mounting so that they are easily identifiable in addition to the labeling already provided by the owner.
3. Office Wall mount Access points identification and installation.
- a. All locations shall have labeling consistant with wall plate labeling specified in 27 11 16 0.
  - b. All locations shall have a duplex wall box and have 2 network drops provided to the location. No wall plate is required.
  - c. All wall mount access points and necessary brackets will be provided by the owner and the contractor will mount the access points in accordance to the designated location and methods required by the specific mounting type, after the cable is tested / certified.
  - d. The acces point will have the first network drop connected to the Pass-Thru port and the second to the access point port.
  - e. The contractor will add the cable labels to top of the Access points after mounting so that they are easily identifiable in addition to the labeling already provided by the owner.
4. General area mount Access Point identification and installation.
- a. All locations shall have labeling consistant with wall plate labeling specified in 27 11 16.0.
  - b. Optimal mounting height is 8 to 12 feet in height from the floor. Exceptions need to be approved by the owner.
  - c. All locations shall have a duplex wall box and have 1 network drop provided to the location. No wall plate is required.

- d. All wall mount access points and necessary brackets will be provided by the owner and the contractor will mount the access points in accordance to the designated location and methods required by the specific mounting type, after the cable is tested / certified.
- e. In some locations protective guards (plexiglass shields) may be required and will be provided by the owner to be installed by the contractor.

### **Requirements for ER/TR data communication equipment Installation**

- 1. The owner will not install the final set of equipment in an ER/TR until the following conditions are completed per the specifications. It will take 3 to 5 days to install and test equipment in each ER/TR once turned over.
  - a. HVAC is operational
  - b. All plywood and significant construction in the room is completed.
  - c. All copper terminations are completed, tested and labeled per the specifications.
  - d. Fiber uplinks to either the appropriated ER or Core networking location is terminated and tested.
  - e. All Power and lighting is installed, labeled and completed. Additionally the power will not be or minimally interrupted.
  - f. ER/TR is cleaned and floor is mopped and sealed.
  - g. ER/TR is lockable with final specified key.
- 2. Interim temporary switches can be installed for critical infrastructure like HVAC and similar systems. Equipment will be a small 8 port switch that will be mounted to the plywood covered wall. However the following must be met and 1 to 3 days are required to install and test equipment in each ER/TR as required.
  - a. Fiber or copper uplinks to either the appropriate ER or Core networking location is terminated and tested.
  - b. Plywood is mounted on the wall nearest the end of the rack row.
  - c. Power and lighting is installed and active.
  - d. ER/TR is lockable / secured during non-working hours.
- 3. Construction related infrastructure network activation requests must be directed to the owner project liaison for proper request processing. Typically HVAC, cameras and similar systems. They can only be completed when either option 1 or 2 above for "Requirements for ER/TR data communication equipment Installation" are completed.

### **Occupant / General Network Access**

- 1. Once the final set of equipment is installed in the ER/TR and the access points are installed / mounted. The wireless should become active in 1 to 3 business days.

2. Network wired ports are activated on request of the occupant. The owner (user support consultant) will work to coordinate identifying and activating the necessary ports through the owner Help Desk system.
3. By default only one (1) network port will be activated per single person office as identified. Second port can be active on request with reasonable justification.
4. All activation requests, if not coordinated by the owner (user support consultant), must be directed through the owner Help Desk by the occupants.
5. Each building is assigned unique sets of IP addresses. Therefore all occupants moving between buildings will be required to re-register their wired devices for a new IP address before it will function.
6. Port activation SLA is typically 1 working day unless there are multiple activities occurring (i.e. start of the semester etc.) that may extend this delivery time. It will be on a first come first serve best effort process.
7. Occupants should plan to bring any existing network cables currently connected to their devices from their previous location. Should the occupant need a different length cable they can request one through the owners help desk. All office patch cables must be CAT5e or higher.
8. Network jack locations are designated in the construction plan. Should occupants disagree with the location and want to add an new jack they must:
  - a. If the building has not been turned over and while the project is still under way, then they must work with the owner Facilities Management team and request a change order to the project with justification to have the additional network drop added or relocated.
  - b. If the building has been turned over and the project is officially completed, then they must request any additional network jacks through the owner defined processes and are subject to installation fees per the owner specifications.

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## GENERAL REQUIREMENTS FOR COMMUNICATIONS

### PART 1 GENERAL REQUIREMENTS

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. The following items are additional requirements for Division 27 “Communications” Work.
- B. If after reviewing all documents and drawing there is any questions or doubt, or if a conflict or discrepancy is found between the documents and the drawings, contact the Owner in writing for clarification before proceeding. Clarification will be issued by Addendum.
- C. Each Item below has the Division 01 00 00 specification section number (in parenthesis) of the article where the base requirements are found. The additional requirements are to be considered additive to the Division 01 00 00 section and apply only to Division 27 work.
- D. Each Division 27 Specification Section may add additional requirements specific to that Section.

#### 1.3 REQUIREMENTS

- A. (01 25 00 Substitution Procedures)
  - 1. Substitutions
    - a) All products provided as Work of this Project shall be in compliance with, and meet the physical, functional, and operational requirements of the products as outlined in Part II of each Division 27 specification Section.
    - b) Product Substitutions
      - 1) Substitution requests must be received by the Owner as required by Division 1.
      - 2) No substitutions will be accepted without prior approval. Only changes issued in an Addendum will be allowed.
      - 3) See Substitution Submission below.
    - c) Standard of Quality
      - 1) A Standard of Quality will be set by applying a Manufacturer and Catalog number to each item in Part II of each applicable specification section.
      - 2) A standard of quality item has the physical, functional, and operational attributes to provide the designed functionality.

- 3) Additional approved manufacturer(s)
  - i) Listing as an additional approved manufacturer for an item is not an assurance that the manufacturer has products that meet the requirements; at minimum, the written description must be met along with any key attributes used in the Project design.
  - ii) When a listed “additional manufacturer” has a product that meets the written description and has the physical, functional, and operational attributes, that product may be used in place of the product that was listed as the standard of quality without submission for prior approval.
    - (A) If such a substitution is made, the requirements for items by the “same manufacturer” shall be adhered to.
      - (1) Requirements for “system” type warranties requiring the same manufacturer or manufacturing “partnership” items for warranty application shall be adhered to.
    - (B) It will be the sole responsibility of the Contractor to provide adequate design compensation for fulfillment of the intent of the Specification for any change in Scope due to an “approved manufacturer’s” product change from this Section (i.e., required rack space, box size, support requirements, etc.).
      - (1) Adequate compensation shall be determined by the Owner.
- 4) Where 2 or more Manufacturers and Catalog numbers are listed, one of the two products must be utilized. Item listed first is Owner’s preferred product.

B. (01 25 13 Product Substitution Procedures)

1. Substitution Submission

- a) Each item submitted must meet the physical, functional, and operational attributes of the Standard of Quality item.
- b) All requests for substitutions shall be accompanied by a complete system brochure and/or individual product data sheets.
  - 1) Contractor shall state a reason for the substitution request (i.e. familiarity, availability, functionality, Brand specific training, Manufacturer’s warranty issue, etc.)
  - 2) Contractor shall provide comparison list of features, functions and specifications where proposed substitute product differs from specified product.
  - 3) Each request must reference the Specification Section number and paragraph and include a description of any deviation from the specified functional requirements of the equipment and/or system(s).

- 4) A demonstration of the proposed equipment and/or system(s) may also be requested. This information must be submitted in compliance with Division 1 Section "Substitutions."
- c) Failure to provide all information may result in the substitute product being rejected.
- d) Owner reserves the right to reject any substitute.
- 2. Substitution Responsibility
  - a) Contractor shall be responsible for all additional costs, both direct and indirect, including costs for additional equipment, materials and labor necessary to properly integrate a substitute product, including additional costs which may be incurred by other trades, the Owner, Architect or Owner. (i.e., required rack space, box size, support requirements, etc.).

C. (01 26 13 Requests for Interpretation)

1. Contradictions, discrepancies, or conflicts

- a) This Contractor shall carefully study and compare the Contract Documents and shall at once report to the Authority as set forth in 01 31 00 "Project Management and Coordination" any error, inconsistency or omission discovered.
- b) In the case of a contradiction, conflict, or discrepancy between Division 27 Sections and Divisions 0 and/or 1.
  - 1) Division 27 Specifications will be considered additive. It is not intended that Division 27 Sections supersede any legal or contractual requirements set forth in Division 0 or 1.
- c) In the case of a contradiction, conflict, or discrepancy between T Series Drawings and/or Division 27 Specification Sections
  - 1) If during the Bid period the Contractor discovers a contradiction, discrepancy, or conflict of information on any Drawing, between any two drawings, between Drawings and specification Sections, within any Division 27 Section, between related Sections, between individual parts of a Section, or within any part of any Section; the contradiction, discrepancy, or conflicting information shall be called to the attention of the Owner in writing and will be clarified by Addendum.
  - 2) A contradiction, discrepancy, or conflict of information that has not been clarified in writing at Bid time will be considered to be the more costly of the available options.
  - 3) If a contradiction, discrepancy, or conflict of information is discovered after award of Contract; the discrepancy or conflict will be submitted to the Owner in writing for evaluation. The result will be clarified by a Change Order. This Change Order will be of \$0 or will require a deduct to change the requirement to a less costly option if so decided by the Owner.
    - i) If Contractor performs any construction activity knowing it involves a recognized contradiction, discrepancy, or conflict in

the contract documents without such notice to the Owner or Owner, the Contractor shall assume appropriate responsibility for such performance and shall bear an appropriate amount of the cost required for correction.

D. (01 31 13 Project Coordination)

1. Coordination

- a) Coordination shall commence immediately upon award of contract. Failure of this contractor in coordinating (including providing and extracting related information to and from other trades for review) in a timely manner, shall not result in any subsequent additional reimbursement, special allowances or additional construction time being made for any facet of the project. Work fabricated or installed before properly coordinating with all other trades shall be done at the Contractor's own risk.
- b) Sequence, coordinate, and integrate installations of communications materials and equipment with the Division 26 electrical contractor any all other applicable trades for efficient flow of the Work.
- c) The contract document drawings are an outline to indicate the approximate location and arrangement of required work. The drawings shall be followed as closely as possible in coordination and in execution of the work.
- d) This contractor shall work in harmony with all building contractors and sub-contractors, so as not to cause any delays in pouring concrete, building masonry walls, etc. This contractor shall consult the Architectural, Plumbing, HVAC and Structural plans in all instances before installing his work so that his work will not interfere with those branches.
- e) This contractor shall participate in coordination efforts and in preparation of coordination drawings prior to fabrication or installation of any equipment, materials, etc. Coordinate actual clearances of all installed equipment.
- f) Conflicts in equipment and materials shall be corrected prior to installation. Should there be a conflict with the drawings of other trades, this contractor shall work with the trades to correct the conflict while coordinating the project (prior to installation). If the conflict cannot be resolved, refer the matter to the owner's representative for a final decision as to method or material. This contractor shall refer to drawings of all other trades for details, dimensions and locations of other work and route their work so as not to conflict with any other branch. Any work installed or equipment placed in position by this contractor creating a conflict shall be readjusted to the satisfaction of the owner's representative at the expense of this contractor.
- g) Plans are diagrammatic indicating design intent and indicating required size, points of termination and, in some cases, suggested routes of raceways, etc. However, it is not intended that drawings indicate fully coordinated conduit routing, all necessary offsets, etc. All cable assemblies, etc. shall be run as straight as possible and symmetrical (perpendicular to or parallel with) with

architectural items and in a consistent elevation. Work installed diagonal to building members shall not be permitted.

- h) The Contractor shall coordinate his work with all other trades and locate equipment accordingly. This Contractor shall refer to coordination drawings of the other trades. Any communications work fabricated or installed before the above referenced coordination with all other trades shall be done at the respective contractors' risk.
- i) It is intended that all apparatus be located symmetrical with architectural elements and shall be installed at exact height and locations as shown on architectural drawings. If a device height or location is in question it shall be the responsibility of this Contractor to immediately seek clarification from the Owner.

E. (01 31 16 Multiple Contract Coordination)

- 1. Coordinate work with Division 26 Contractor (where applicable); prior to Division 26 Contractor's installation of outlet boxes, conduit, conduit stubs, raceways and any other provisions in support of Division 27 Contractor's work.
- 2. Coordinate with all other Contractor's and the Owner, as applicable and necessary to ensure a clean, professional looking and operating systems.

F. (01 31 19.16 Site Mobilization Meetings)

- 1. The Contractor shall fully inform himself regarding all peculiarities and limitations of space available for installation of all work and materials furnished and installed under the contract. He shall exercise due and particular caution to determine that all parts of his work are made quickly and easily accessible. Although the locations of equipment and conduit may be shown on the drawings in certain positions, the architectural details and conditions existing at the job site shall guide the Contractor, coordinating his work with that of others. Provide all offsets as required to provide a neat workmanlike arrangement

G. (01 33 23 Shop Drawings, Product Data, and Samples)

- 1. Submittals required after Award of Contract but before starting Work include:
  - a) Complete BOM list
    - 1) BOM shall include the following information for each product:
  - b) Product Information Sheets "Datasheets": Include catalog information, sizing, and technical data on each item to be used on the Project.
    - 1) Each product datasheet must reference the specific paragraph for which the product is being submitted. Each product must be listed in the exact same order as it appears in the Section for which the products are being submitted.
    - i) Datasheets shall each include a clearly identifiable label applied in upper corner of each sheet that clearly references the specification section and drawing (as applicable) to which it applies. Labels shall be consistently affixed in the same location on all sheets unless the labels will obstruct pertinent technical information.

- 2) All datasheets shall be original manufacture datasheets, first generation printed copies of manufacturer's electronic datasheet (i.e. printed copy of a PDF file), or high quality photocopy of original manufacturer's datasheets.
  - i) Fax versions of product datasheets or any photocopies thereof are not acceptable.
  - ii) Submit original printing or "clean" reproductions.
- 3) Where datasheets depict multiple products, versions or options, the Contractor shall highlight (indicate with an arrow) all applicable model(s), version(s) and option(s) applying to the specific product the Contractor will be providing. Exact catalog number must be indicated. The submitted items must be from "approved materials" as specified in each Specification Section.
- 4) Product datasheets shall be "approved" by the Owner before delivery to the Project site. Any product not approved through the submittal process is at the sole risk of the Contractor.
  - i) A copy of "Approved" datasheets shall be included in O & M manual requirements
- 5) Required Information
  - i) Complete Bill of Materials (BOM) List
    - (A) The manufacturer's name (Brand) and full model number shall be used. (Distributor and Contractor assigned names and model numbers are unacceptable).
  - ii) Manufacturer Product Datasheet for each product.
    - (A) Product datasheets shall be manufacturer originals, or first generation printed versions of manufacturer's official electronic product sheets.
    - (B) Manufacture model shall be highlighted on each sheet.
    - (C) Datasheets shall be organized to match the order and organization of this section

## 2. Submission Format

- a) Submit Shop Drawings and Product Data Sheets in a bound form
  - 1) Submittals shall be supplied in an appropriately sized 3-ring binder(s). Separate binders shall normally be used for each Division 27 Contract.
  - 2) Manuals shall be bound in hard cover, 3 ring binders with clear plastic "pocket" covers to insert Project Information on the exterior of the Binder.
  - 3) Maximum individual Binder spine size shall be 3"; utilize multiple binders as required.

- b) Submittal Manuals shall include the information listed below and be assembled as follows:
    - 1) Binder shall be marked on the cover and spine with the following information
      - i) Project Information
        - (A) Title of Project
        - (B) Name and address of Owner, Contractor, Architect, Owner
        - (C) "Submittals for " (specification Section(s))
        - (D) Date of Submittal
    - 2) Organization
      - i) The binder is subdivided into specification sections.
      - ii) Each Binder shall be organized as follows
        - (A) Master Tab 1: Project and contact information
        - (B) Master Tab 2: (First) Specification Section
          - (1) Section 1: Title Page
          - (2) Specification section name & number
          - (3) Contractor/Subcontractor Information Including:
            - (4) Name, address and phone
            - (5) Project manager name and phone
          - (6) Section 2: Bill of Materials
          - (7) Section 3: Product Datasheets
          - (8) Section 4: 11 x 17 inch reduced scale versions of full size shop drawings. Drawings shall be folded, punched and inserted into the binder.
        - (C) Master Tab 3 through (x): Additional Specification Section(s)
          - (1) Repeat Sections 1-5 above for each Specification Section.
      - iii) Division 27 submittals may not be combined with submittals from any other Division.
    - 3) Full-size shop drawings shall be printed to scale and bound along the left edge of the drawings with the Title block on the right edge.
    - 4) The Contractor shall provide a record of shop drawings using AutoCAD Release 2000 or higher.
      - i) Detail drawings may be submitted in Visio 2000 format.
3. Submission
- a) Provide minimum of (5) copies of all submittal items.
    - 1) Two copies of all Submittals will be retained by the Owner.
    - 2) Three copies will be returned.
      - i) One copy of approved Submittals will be required to prepare Record Drawing for the O&M (Owner's) Manual.
      - ii) One Copy for the Project site
      - iii) One Copy for the Contractor's records

- 3) Provide additional quantities as may be required by other applicable sections (including Division 1), as requested by the Owner, and as required by the Contractor for its own purposes.
  - b) Timetable
    - 1) Contractor shall make all Submittal submissions as soon as practical after award of Contract.
    - 2) Provide submittals in adequate time so as not to negatively impact the completion of the project or the schedule of other trades.
      - i) Contractor shall allow a minimum of 2 weeks in its schedule for the Owner's review of submittals.
4. Review of shop drawings does not relieve the Contractor of responsibility for correct ordering of material and equipment. Contractor review should ensure that equipment will fit in available space.
  - a) **PARTIAL OR INCOMPLETE SUBMITTALS WILL BE REJECTED PRIOR TO FULL REVIEW.**
  - b) Unacceptable submittal items:
    - 1) Fax copies of datasheets
    - 2) Datasheets that are not legible.
    - 3) Datasheets that do not clearly depict and/or enumerate all specification requirements.
    - 4) Non-manufacture datasheets (i.e. from a distributor)
    - 5) HTML web page printouts that are not the manufacturer's official product datasheet.
    - 6) Identification of products by Contractor or Distributor assigned part numbers, catalog numbers or private label brand names.

#### H. (01 41 13 Codes)

##### 1. Building Codes:

- a) National Electrical Code (NFPA 70)
- b) Life Safety Code (NFPA 101)
- c) Uniform Building Code (Or adopted State Code)
- d) Federal Communications Commission (FCC) Part 68
- e) State specific agencies:
  - 1) Administrative Building Council
  - 2) State Board of Health
  - 3) State Fire Marshal

- f) Local Codes (City, County, etc.)
- g) Local Utility Company requirements

I. (01 41 26 Permits)

1. Contractor shall obtain and pay for all permits or certificates of inspection and approval required for his branch of the work.
  - a) Permits shall be posted in a prominent place at the building site properly protected from weather and physical damage.

J. (01 42 16 Definitions)

1. Wherever the words "Contractor", "This Contractor" or "Subcontractor" appears in Division 27 specifications, it shall refer to the Division 27 Communications Contractor (or Subcontractor of the Communications Contractor where applicable).
2. A reference to Owner shall be referring to the Owner's Representative involved in the design of the System(s). The Owner may or may not be affiliated with the Architect and or Engineer for the Project. All information exchanged between the Contractor(s) and the Owner shall be within the information exchange process of the Project. (i.e. through a Construction Manager, General Contractor, Architectural Firm, etc.)
3. Wherever the words "Designer", "Consultant" or "Engineer" appears in Division 27 specifications or its related drawings, it shall be interpreted to mean the specifying authority responsible for the creation of the Division 27 specifications and related drawings.
4. Wherever the word "Install" appears on the drawings or in these Division 27 specifications it shall mean to supply all labor, tools and incidental materials necessary to handle, store, mount, terminate, program, configure and adjust product as necessary to fulfill project requirements.
5. Wherever the word "Provide" appears on plan drawings or in Division 27 specifications, it shall be interpreted to mean that the Contractor shall "Furnish and Install", including all necessary accessories, miscellaneous materials and labor necessary to render the respective system fully operational.
6. Wherever the word "Work" appears in Division 27 specifications or on communication technology drawings, it shall be interpreted to mean any and all labor, materials, accessories, services, etc. necessary to fulfill project requirements.
7. Wherever the word "Furnish" appears on the drawings or in these Division 27 specifications it shall mean to supply the specified labor or specified product (context dependant), including all associated shipping, storage and warranty expenses.
8. Wherever the words "Site", "Project Site", or "Premises" appears in Division 27 specifications or its related drawings, it shall be interpreted to mean all real estate,

- buildings and structures where work will be performed and where products will be installed and reside.
9. Wherever the phrase “or Approved equal” appears in Division 27 specifications or its related drawings, the contractor shall interpret this to mean that pre-bid approval of specific models of equipment is required before submission of the Contractor’s bid.
  10. Wherever the phrase “or Equal from”, or “or Equal by” appears in Division 27 specifications or its related drawings, the Contractor shall interpret this to mean that the Contractor may supply any product manufactured by the given list of manufacturer’s meeting or exceeding the overall quality, functional, technical performance, construction, finish and general fit and fitness as the “Standard of Quality” design product. The final authority as to whether a product is equal shall remain with the Owner. Pre-bid approval is highly recommended.
  11. Wherever the phrase “Additional Approved Manufacturer(s)” appears in Division 27 specifications or its related drawings, the Contractor shall interpret this to mean that the Contractor may supply any product manufactured by the given list of manufacturer’s meeting or exceeding the overall quality, functional, technical performance, construction, finish and general fit and fitness as the basis of design product. The final authority as to whether a product is equal shall remain with the Owner.
  12. Wherever the phrase “Standard of Quality” appears in Division 27 specifications or its related drawings, the Contractor shall interpret this to mean that the listed Manufacturer and Catalog number for each item has the physical, functional, and operational attributes to provide the designed functionality.
  13. Substantial Completion:
    - a) The point at which the following has been completed:
      - 1) All specified work, and;
      - 2) All punch-list items that affect the full and complete use of the system, and;
      - 3) Successful acceptance testing by the Owner, and;
      - 4) Successful inspection and demonstration of the work to the Owner’s representative, and;
      - 5) Contractor’s delivery of a request for “Letter of Substantial Completion”
        - i) The request shall include the Specification Section(s) completed, confirmation of completion of the items listed above, and the requested Substantial Completion date (no more than 7 calendar days prior to this Letter).
      - 6) Contractor has received a Letter of substantial Completion for the Owner.
  14. Nominal Operating Levels: The standard signal voltage/power reference level which a manufacturer has designed its product’s inputs and outputs to operate at to achieve the manufacturer’s specified performance levels.

15. Wherever the words “This Division” appears in Division 27 specifications or its related drawings, it shall be interpreted to mean these Division 27 specifications and all of its related drawings.
  16. Wherever the words “Low Voltage”, or “Low-Voltage” appears in Division 27 specifications or its related drawings, it shall be interpreted to mean less than or equal to 70.7 volts, AC or DC.
  17. Wherever the words “High Voltage”, or “High-Voltage” appears in Division 27 specifications or its related drawings, it shall be interpreted to mean greater than 70.7 volts, AC or DC.
- K. (01 43 00 Quality Assurance)
1. Quality Assurance
    - a) Requirements
      - 1) Contractor shall have a minimum five (5) years experience in the installation of Communication Technology system(s) of similar size, type, scope and contract value.
      - 2) The Prime Contractor or his subcontractor responsible for this Section shall have a Registered Communications Distribution Designer (RCDD) on staff that will be ultimately responsible for this Project. The RCDD must have sufficient experience in this type project as to be able to lend adequate technical support to the field forces during installation, the warranty period, and any extended warranty periods or maintenance contracts. If in the opinion of the Owner, the RCDD does not possess adequate qualifications to support the Project, the Owner reserves the right to require the Contractor to assign an RCDD who, in the Owner’s opinion, possesses the necessary skills and experience required of this Project.
      - 3) The lead technician(s) on the Project shall carry a current BICSI Technician Certificate or have five years of experience in projects of similar scope.
      - 4) The lead technician(s) on the Project shall have a thorough understanding of the following:
        - i) American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 568B Commercial Building Telecommunications Cabling Standard.
        - ii) American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and spaces.
        - iii) American National Standards Institute/Telecommunications Industry Association – ANSI/TIA/EIA 606 The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.

- iv) American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
- 5) Contractor shall be a (factory trained) certified installer for all connectivity products.(cable and terminations).
  - i) This minimum requirement shall apply to each Division 27 section independently. If Contractor is incapable of meeting the percent of product value requirement for each section, Contractor shall use a Subcontractor that can meet the percent of product value requirement, in whole, for all products and work of that section for which This Contractor is not qualified.
  - ii) The specific Contractor or Subcontractor meeting the requirements for a specific section shall be responsible for the supply of the products, supplemental engineering services and submittals as well as performing all technical labor associated with the installation, training and warranty servicing of work of that section.
- 6) Contractor shall have substantial business operations located within a 100 mile radius of the project site with a full-time employee staff actively engaged in the supply, installation and service of systems and equipment of the type and scope herein specified.
- 7) Contractor shall have full-time employee service staff based within a 100 mile radius of the project site.
- 8) Contractor shall provide any additional information requested by the Owner as determined appropriate by the Owner to validate a Contractor's (or its Subcontractor's) ability to perform and warranty the specified work in the quality, manner and time frame required.
- 9) In the absence of a requirement to provide a performance bond the Designer reserves the right to require a financial disclosure of the Contractor and any Subcontractor for the purpose of aiding the Designer in determining the ability of the Contractor or Subcontractor to perform.
- 10) Designer reserves the right to disqualify the use of any Subcontractor that This Contractor plans to use if the Subcontractor fails to meet the quality assurance requirements. Should this occur, This Contractor shall be required to choose another Subcontractor that does meet these quality assurance requirements.
  - i) An equipment vendor not performing the technical labor associated with installation of the work of a given section shall not be considered a Subcontractor.
- 11) Superintendent/Project Manager
  - i) This Contractor shall furnish the services of an experienced superintendent/Project Manager who shall be constantly in charge of the work, together with the qualified Foremen and

- specialists as required to properly install, connect, adjust, start, operate and test the work involved.
- ii) The superintendent's/Project Manager's qualifications shall be subject to the review and acceptance by the Owner/Owner. Unless the Owner/Owner grants prior special permission, the same communication Superintendent/Project Manager shall be utilized throughout the duration of the project and be responsible for the complete scope of the Contract.
- b) Documentation to be submitted upon request pre or post bid for evaluation includes:
- 1) A complete material list by specification section for each specification section:
    - i) Include description, the manufacturer being used, and the manufacturer's part number.
    - ii) Submission of this list does not constitute acceptance by the Owner or relieve the Contractor from providing approved items in the proper quantities to fulfill the Scope of this Project.
  - 2) References:
    - i) A minimum of five reference accounts at which similar work, both in scope and design for each system specified, has been completed by the Contractor within the last four years.
      - (A) The list shall include contact names and telephone numbers for each.
      - (B) Each listed Project shall include a Summary of Work.
      - (C) Each listed Project shall include initial and final contract amounts.
      - (D) Each listed Project shall include initial Contract award date and completion date.
      - (E) Each listed Project shall identify the name of Contractor's project manager and lead technician responsible for the project.
  - 3) List of test equipment:
    - i) Proposed equipment for use in verifying the installed integrity of copper and fiber optic cable systems on this Project.
  - 4) Technical resume:
    - i) Provide experience of the Contractor's Superintendent/Project Manager and onsite installation supervisor (Foreman) who will be assigned to this Project.
  - 5) List of technical product training:
    - i) Training attended by the Contractor's personnel that will be working on this Project.
  - 6) Subcontractors list for Work of this Project.
    - i) List Scope of Work for each Subcontractor
    - ii) List References for each subcontractor
    - iii) Technical resume as described above for each subcontractor

- iv) List of technical product training as described above for each subcontractor.
  - 7) Each specification section may detail additional Quality Assurance requirements in the PART I, Quality Assurance paragraph.
    - i) Submit each item identified in each Specification Section.
      - (A) Manufacturer Certification documentation as requested in each Section.
  - 8) Documentation substantiating the Contractor's factory authorization and warranty service status for all products specified and all other major products proposed for use by the Contractor.
  - 9) Financial Disclosure.
  - c) Failure to supply a complete quality assurance submittal; failure to supply accurate references or references which yield favorable performance marks; or failure to supply other quality assurance information required shall be taken as a statement of the Contractor's inability to perform and shall be grounds for the Owner and/or Owner to reject the Contractor's bid.
- L. (01 62 00 Product Options)
1. The contract documents are prepared on the basis of a single specific product as the "design equipment," even though other manufacturers' names and models may be listed as acceptable, or equal. The first manufacturer make and model for each product is the "design equipment" or "Standard of Quality".
    - a) This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
    - b) This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
    - c) Project design is based on the "Standard of Quality" listed products' physical, functional, and operational attributes. The use of any product not listed as the Standard of Quality must be compared for full functionality to the listed Product.
    - d) When several materials, products or items of equipment are specified by name for one use, the first item shall be considered Owner's preferred product. Contractor may select any one of those specified for requested approval. It shall be the responsibility of the Contractor to provide an item that meets or exceeds the qualities and functional characteristics of the device specifically listed by brand name and model number.
    - e) The Contractor is responsible for any other ancillary changes required to meet the Project objectives when utilizing substitutions. Approval of items submitted during the submittal process does not relieve the Contractor of this responsibility.
  2. Product acceptability and substitutions are determined by criteria as required this section under "Substitutions".

3. Materials installed shall be new, full weight and of the best quality. All similar materials shall be of the same type and manufacturer. All materials, apparatus and equipment shall bear the Underwriter's Laboratory, Inc. label where regularly supplied, or required by Code.
4. In the event that a specified product is discontinued by the manufacturer and is no longer available for purchase, the Contractor shall provide replacement product of equal or greater value, performance and function. The replacement product shall be from the same manufacturer as the specified equipment unless written approval to use an alternate manufacture is obtained from the Owner.

M. (01 65 00 Product Delivery Requirements)

1. Product Procurement

- a) The Contractor shall not procure, deliver or install any product until after the contractor's submittal has been reviewed by the Owner and the submittal has been returned to the Contractor's marked "No Exceptions", "Exceptions Noted" or "Exceptions Noted, Submit Record Copy" or "Approved". Advance procurement, delivery or installation of product prior to the return of submittal is entirely at the Contractor's own risk. Contractor should schedule its work and procurement accordingly.
- b) Prior to procurement of any equipment or materials, Contractor shall review the model numbers, compatibility and interoperability of all products.
- c) Prior to procurement, Contractor shall, through coordination with other trades and through field measurements and project site inspections, verify that products to be supplied can be physically installed as planned.
- d) No claim for additional payment will be considered for the return of any equipment determined incompatible, or procured without adhering to the aforementioned conditions, including claim for reimbursement of manufacturer's "restock" fees.
- e) Contractor shall factor all of these conditions into its bid and plan its scheduling and resource needs accordingly to ensure that all work shall be performed according to the Owner's schedule and requirements of this contract.

N. (01 66 00 Product Storage and Handling Requirements)

1. Product Delivery, Storage and Handling

- a) Receipt of materials
  - 1) The Contractor is responsible for receiving, handling, storing, and protecting all materials used on this Project until Substantial Completion.
- b) Upon request, submit a schedule of equipment and materials required to complete installation, quantity ordered, order date, and promised delivery date.
- c) Deliver equipment and materials in accordance with factory shipping requirements.
  - 1) Pack components in factory-fabricated protective containers.

- 2) Units shall be delivered in sections of such size as will pass through available openings.
  - d) Until ready for installation, store products in original factory containers.
    - 1) Products shall be stored in a clean, dry space and as additionally recommended by the product manufacturer.
    - 2) Keep products out of the weather and away from construction traffic and debris, including drywall finish dust.
    - 3) Do not exceed structural capacity of the floor or platform on which the products are stored.
  - e) Until final acceptance of the system, protect all supplied products from damage resulting from moisture, fumes, dirt, dust and debris or any other source of potential damage.
  - f) Handle all products with care before, during and after installation so as to prevent damage.
    - 1) Replace any products damaged prior to final acceptance with new replacement products.
      - i) Replacement shall be done at not charge to the owner.
    - 2) Contractor is responsible for the safety and good condition of the materials and equipment installed until final acceptance by the Owner.
  - g) Save original product shipping containers and related packaging materials for major products until final acceptance.
    - 1) Prior to disposal, check with owner to determine if the owner wishes any of the packaging materials.
    - 2) Deliver specified packaging materials to the owner as requested.
- O. (01 71 00 Examination and Preparation)
- 1. Examination of the Site
    - a) Contractor shall visit the Site to familiarize himself with the local conditions under which the work is to be performed and correlate his observations with the requirements of the Contract Documents. No allowance shall be made for claims for concealed conditions which the Contractor, in exercise or reasonable diligence in observations of the Site and review of the local conditions under which the work is to be performed, learned or should have learned of, unless otherwise specifically agreed by Owner and Owner in writing.
    - b) Before ordering any materials or doing any work, the Contractor shall verify all measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of an unverified difference between an actual dimension and the measurement or size indicated in the drawings or specifications. Any discrepancies found shall be submitted in writing to the Project Manager and Owner for consideration before proceeding with the work.
    - c) This Contractor must verify all dimensions locating the work and its relation to existing work, all existing conditions and their relation to the work and all

man made obstructions and conditions, etc. affecting the completion and proper execution of the work as indicated in the Contract Documents.

P. (01 73 19 Installation)

1. Work and workmanship

- a) Provide all required labor, materials, equipment and Contractor's services necessary for complete installation of systems required to comply with the requirements of authorities having jurisdiction, as indicated on Drawings, and as specified.
- b) Work shall be functional and complete in every detail, including any and all items required to complete the system, whether or not these items have been enumerated or shown on the Drawings.
- c) Special attention shall be given to access to working and controlling parts. Adjustable parts shall be within easy reach. Removable parts shall have space for removal.
- d) Each Contractor shall be fully knowledgeable of the details of all Work to be performed by other trades and take necessary steps to integrate and coordinate his Work with other trades.
- e) Wherever tables or schedules show quantities of materials, they shall not be used as a final count. These figures serve only as a guide for the Contractor. Each Contractor shall be responsible for furnishing all materials on the Drawings or as specified.
- f) The Consultant and Owner's Representative have full power to condemn or reject any Work, materials or equipment not in accordance with these Specifications and Construction Drawings or the manufacturer's specifications or drawings approved by the Owner or Consultant.
- g) Work or equipment that is rejected shall be removed and replaced to the satisfaction of the Owner at the Contractor's expense. Work or equipment that is rejected shall be so stated in writing by the Owner or Consultant.
- h) Such decisions that the Owner or Consultant may make with respect to questions concerning the quality, fitness of materials, equipment, and workmanship shall be binding upon the parties thereto.
- i) All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.
- j) All Work shall be performed with the best practices of the trade for performance, functionality, safety, endurance, and aesthetics.
- k) Coordinate ordering and installation of all equipment with long lead times or having a major impact on work by other trades so as not to delay the job or impact the schedule.
- l) Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible, as appropriate to the application.
- m) Set all equipment to accurate line and grade, level all equipment and align all equipment components.

- n) Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from premises when no longer required.
- o) No equipment shall be hidden or covered up prior to inspection by the owner's representative. All work that is determined to be unsatisfactory shall be corrected immediately.
- p) All work shall be installed level and plumb, parallel and perpendicular to other building systems and components.
- q) Install all equipment and materials in strict accordance with manufacturer's written instructions. Bring any conflicts between the manufacturer's written instructions and these specifications to the attention of the Designer for recommendations.
- r) Upon completion of installation of equipment and communication circuitry, energize circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with re-testing.

Q. (01 73 29 Cutting and Patching)

- 1. Where demolition of existing surfaces are required by the Work, the same shall be restored to at least as good a condition as they were before.
- 2. Contractor shall be responsible for painting, patching, repairing and replacing any building surface, furnishing, wall/floor/ceiling covering that is damaged or penetrated in the process of performing work on the project site.
- 3. Additional work required to repair work performed under this Contract shall be at the expense of This Contractor.
- 4. The Division 27 contractor shall do all cutting as required for the admission of Division 27 work. Unless directed otherwise in field, provide all related patching and painting to match surrounding methods, materials and colors. Any damage done by this contractor to the building during the progress of this contractor's work shall be made good at this contractor's expense. Perform cutting, fitting, and patching and materials as required to:
  - a) Uncover Work to provide for installation of ill-timed Work.
  - b) Remove and replace defective Work.
  - c) Remove and replace Work not conforming to requirements of the Contract Documents.
  - d) Remove samples of installed Work as specified for testing.
  - e) Install equipment and materials in existing structures.

- f) Upon written instructions from the owner's representative, uncover and restore work to provide for observation of concealed work by owner's representative or by inspection authority having jurisdiction.
  - g) During cutting and patching operations, protect adjacent installations (structure, finishes, furnishings, etc.). Where applicable, provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to system components and components of other trades.
  - h) Patch surfaces and building components using new materials matching existing materials and using experienced Installers. Refer to Division 1 for definition of experienced "Installer" or determine qualifications as directed in field by owner's representative.
  - i) Patching through fire rated walls and enclosures shall not diminish the rating of that wall or enclosure. All materials used for patching shall be installed to meet or exceed the smoke and fire rating of the respective surface being patched.
  - j) Neatly cut and drill all openings in walls and floors required for the installation. Secure approval of Owner's Representative before cutting and drilling in existing facilities. Neatly patch all openings cut.
  - k) Cutting and patching shall be held to a minimum by arranging with other contractors for all sleeves and openings before construction is started.
  - l) Provide factory-assembled watertight wall and floor seals, of types and sizes required; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.
  - m) Pipe sleeves shall be fabricated from Schedule 40 rigid, heavy wall, full weight galvanized steel pipe; remove burrs. Use sleeves which are two standard sizes larger than conduit passing through respective sleeve.
  - n) Provide sleeve seals for piping which penetrates foundation walls below grade, exterior walls or roofs, caulk between sleeve and pipe with non-toxic, UL-classified caulking material to ensure watertight seal. Elsewhere modular provide mechanical type seals, 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.
  - o) Install standard Schedule 40 black steel pipe sleeves two sizes larger than pipes passing through floors, bearing walls, fire walls and masonry construction. Sleeves through walls shall be cut flush with both faces. Sleeves through floor shall extend one inch above floor top elevation. Pipes penetrating roof shall use a pipe curb assembly equal to Pate Co. Furnish and set all forms required in masonry walls or foundation to accommodate pipes.
5. Grout

- a) Provide non-shrink, nonmetallic grout, premixed, factory-packaged, non-staining, non-corrosive, nongaseous grout, recommended for interior and exterior applications.
- 6. General Joint Sealer Application
  - a) Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
  - b) Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.
  - c) Clean all affected surfaces, joints, etc. immediately before applying joint sealers to comply with recommendations of joint sealer manufacturer.
  - d) Apply sealant primer to substrates as recommended by manufacturer. Protect adjacent areas from spillage and migration of sealant, using masking tape. Remove tape immediately after tooling without disturbing seal.
  - e) Comply with joint sealer manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
  - f) Comply with recommendations of ASTM C 962 for use of elastomeric joint sealers.
  - g) Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.
  - h) Immediately after sealant application and prior to time skinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
  - i) Colors for exposed seals shall be as selected by the Owner's representative from manufacturer's standard colors.
- 7. Elastomeric Joint Sealers
  - a) One-part, nonacid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
  - b) One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and nonporous joint substrates; formulated with fungicide; intended for sealing interior joints with nonporous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes. Silicone Sealant shall be equal to the following:
    - 1) "Dow Corning 790", Dow Corning Corp.
    - 2) "Gesil N SCS 2600", General Electric Co.
    - 3) A/D Fire Protection Systems.
- 8. Acrylic-Emulsion Sealants

- a) One-part, non-sag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications or interior and protected exterior locations involving joint movement of not more than plus or minimum 5 percent. Subject to compliance with requirements, provide one of the following:
  - 1) "Chem-Calk 600", Bostik Construction Products Div.
  - 2) "AC-20", Pecora Corp.
  - 3) "Sonolac", Sonneborn Building Products Div.
  - 4) "Tremco Acrylic Latex 834", Tremco, Inc.
- R. (01 74 16 Site Maintenance)
  - 1. During the progress of the work, the Contractor shall clean up after his men and leave the premises and all portions of the building in which he is working in a clean and safe condition. This cleaning shall occur on a daily basis.
- S. (01 74 23 Final Cleaning)
  - 1. Clean all parts of the apparatus and equipment. Exposed parts, which are to be painted, shall be cleaned of cement, plaster and other materials and all oil and grease spots shall be removed. Such surfaces shall be carefully wiped and all corners and cracks scraped out.
- T. (01 77 16 Final Closeout Review)
  - 1. Project Closeout
    - a) Contractor shall meet all provisions of Substantial completion as defined earlier in this section and in each related section.
    - b) Final Payment
      - 1) Final payment of contract will not be made until receipt, review and acceptance, by the owner's representative, of all of the following:
        - i) Substantial Completion
        - ii) Completion of all punch-list items.
        - iii) Approved submittals, including shop drawings;
        - iv) Owner's manuals;
        - v) Record documentation;
        - vi) Certification of warranty;
        - vii) Certificate of final acceptance signed by the Owner and the Owner;
        - viii) Copies of all training sign-in sheets, signed by owner's representative;
        - ix) Signed delivery receipt indicating that the owner has received all training recordings produced to-date;
        - x) All additional applicable closeout provisions of Division 1;
    - c) 100% of all closeout documents shall be supplied within 30 calendar days following the substantial completion.
- U. (01 77 19 Closeout Requirements)

1. Acceptance Testing

- a) Upon the Designer's receipt of and approval of the Contractor's pre-test submittal, the Contractor shall contract the Designer to schedule acceptance testing. Contractor shall allow not less than 10-business days of advance notice to the Owner.
- b) In the presence of the Owner, the Contractor shall demonstrate the presence of all specified products, cabling and installation methods. The Contractor shall demonstrate the operation of the system (and any requested sub-component thereof) and shall be prepared to make any electronic, physical or software related adjustments to the system or any of its sub-components to the satisfaction of the Owner, as required to achieve full compliance with the specifications.
- c) The contractor shall have available at the project site all test equipment, cables, tools and personnel necessary to demonstrate full compliance with these specifications as determined necessary by the designer.
- d) During the acceptance testing the Contractor shall have a clean and fresh copy of the contractor's most up-to-date as-built record documentation, printed to scale.
- e) This Contractor shall provide all required labor services required to completely verify and test the systems in the presence of the Owner.
- f) Verify that each system, as a whole system, meets these Specifications and complies with all applicable standards.
- g) Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense.
- h) Should the Owner be required to return to the project site to perform acceptance testing more than once for any system the Contractor shall be responsible for all costs, up to \$1500 per day, plus travel and expenses, for each return trip to the project site. Payment of this may be required before final payment will be authorized.

2. Supplemental Engineering Services

- a) This Contractor is responsible for all supplemental engineering services specifically outlined in these specifications and otherwise required for the completion of the work specified. Contractor shall estimate its costs accordingly, taking into account all information provided.
- b) In the event that the Owner is required to provide additional services as a result of Contractor's errors, omissions or failure to conform to the requirements of the Contract Documents, or if the Owner is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Owner's expenses in connection with such additional services shall be paid by the Contractor and may either be deducted from any monies owed to the Contractor, or billed to the contractor, entirely at the discretion of the Owner. The contractor shall be billed at prevailing hourly rates.

- c) In the event that the Owner is required to provide additional services as a result of substitution of equivalent materials or equipment by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Owner is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Owner's expenses in connection with such additional services shall be paid by the Contractor. Costs will be calculated based upon the Owners prevailing rates.

V. (01 78 13 Completion and Correction List)

- 1. Owner shall be furnished with a certificate of final inspection and approval prior to final acceptance of this branch of the work.

W. (01 78 36 Warranties)

1. Warranty Period

- a) Specified materials and workmanship provided shall be fully guaranteed by the Contractor for one year from the transfer of title via notice of substantial completion against any defects in materials or workmanship.

- i) Extended (additional) warranty(ies) may be required and will be identified in the individual Specification Section and will be considered additive to this base Contractor Warranty.

- ii) Requirements for Manufacturer's Warranties, required by a Specification Section, shall run concurrent to this base Warranty by the Contractor but may exceed the Contractor's Warranty Period.

- 2) Manufacturer's Warranties shall also begin on Substantial Completion; not on purchase of equipment or delivery of equipment to the site.

- b) The Warranty shall begin upon Substantial Completion.

- 1) Note: Delivery of closeout documents is not a conditional requirement to commencement of the warranty.

- 2. This warranty shall in no manner cover equipment that has been damaged or rendered unserviceable due to negligence, misuse, acts of vandalism, or tampering by the Owner or anyone other than employees or agents of the Contractor.

- a) The Contractor's obligation under its warranty is limited to the cost of repair of the warranted item or replacement thereof, at the Contractor's option.

- b) Insurance covering said equipment from damage or loss is to be borne by the Contractor until full acceptance of equipment and services.

- 3. Individual specification sections may have additional warranty requirements for the work in that section. The warranty above will cover all materials and work where not covered by an extended warranty listed in the individual specification section.

4. Warranty Coverage

- a) Specified materials and workmanship provided shall be fully guaranteed by the Contractor against any defects in materials or workmanship.

- 1) Contractor shall provide a full "System Warranty" which shall cover all materials, labor and related product shipping expenses for a period of five years from the date of Owner acceptance.
  - i) Supplied products with manufacturer's warranties of less than the System Warranty term shall be extended by the Contractor for the full specified term
- 2) During this period the Contractor will remedy (at no cost to the owner) any problem with the system, or any of its related components that is the result of defective materials, settings, workmanship, or loss or programming.
- 3) Any defective items or work shall be removed and replaced at the Contractor's expense to the satisfaction of the owner's representative and the Owner.
- 4) During the Warranty Period, the Contractor shall respond by phone within four (4) business hours of notice by the owner of a problem. Within (1) business day or (72) contiguous hours, which ever comes first, the Contractor shall have qualified personnel onsite to remedy the problem if the problem cannot be quickly be remedied over the phone.
  - i) The contractor shall make available to the owner on-call emergency response service labor to the Owner. Cost for emergency service labor during the warranty period shall not exceed the Contractor's published emergency service rates, or two-times its standard rate, whichever is lower.
- 5) The period of the Contractor warranty(ies) for any items herein are not exclusive remedies, and the Owner has recourse to any warranties of additional Scope given by the Contractor to the Owner and all other remedies available by law or in equity.
- 6) Additional Warranty requirements may be added by an individual Specification Section.
  - i) Scope of these extended (additional) warranty(ies) will be identified in the individual Specification Section and will be considered additive to this base Contractor Warranty.
  - ii) Requirements for Manufacturer's Warranties, required by a Specification Section, shall run concurrent to this base Contractor Warranty by the Contractor.
    - (A) Manufacturer's Warranties shall also begin on Substantial Completion; not on purchase of equipment.

X. (01 78 39 Project Record Documents)

1. Project Record Document requirements for Division 27 "Communications" shall be described in Section 27 01 00 "Operation and Maintenance of Communications Systems".

Y. (01 79 00 Demonstration and Training)

1. Training

- a) Proper operation in many cases is a function of adequate training of key users on new systems.
  - 1) Each Division 27 section may specify special Training requirements.
    - i) Training requirements will be for a quantity of hours, allow for multiple trips.
  - 2) If no special requirements are specified in the individual section, allow for 4 hours and 2 trips to provide basic overview, operation and maintenance information.
  - 3) Each Specification Section will indicate any training criteria specific to that Section.
  - 4) Train Owner's maintenance personnel on the procedures and schedules involved in operating, general troubleshooting, and preventative maintenance of the system.
  - 5) All training sessions shall be audio and video recorded. Recordings shall be supplied in DVD formats and playable on standard consumer grade reproduction equipment. Recordings do not need to be professionally edited but shall have intelligible audio and a clear image of the subject trainer and any supplemental visual content critical to the training.
  - 6) Recordings shall be turned over and signed for by an owner's representative at the end of each training session.
  - 7) Contractor shall require all attendees to sign-in for each training session. The sign-in form shall summarize the training to be conducted, specification section and subsection being trained on, as well as the starting time and duration of training. Following training, a representative of the owner shall sign the form, acknowledging the same. Contractor shall retain the original copy of these forms and turn over a photo copy of the form to the owner's representative as evidence of training. Training conducted without this official record of training shall not be considered as part of the Contractor's training obligation.
- b) Schedule training with the Owner's representative, at least 14 days in advance.
- c) Contractor shall assume training will be conducted in a minimum of (2) separate sessions, on non-contiguous days and will require separate trips to the project site, and should be bid accordingly.
- d) Owner shall have the right to use its allocated training for a period of 365 calendar days following acceptance of the system.

**END OF SECTION 27 00 10**

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## **OPERATION AND MAINTENANCE OF COMMUNICATIONS SYSTEMS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Basic materials, methods and installation guidelines applicable to the installation of all communication systems.
    - a) This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
- B. Related Sections
  - 1. All Division 27 Sections.
- C. Related Drawings
  - 1. All Technology (T-Series) Drawings

#### **1.3 RECORD DOCUMENTS FOR COMMUNICATIONS SYSTEMS**

- A. The Operations and Maintenance Manual (Owner’s Manual) paragraph below details the basic information required to be documented.
- B. Each specification section will detail applicable additional Record Document requirements in the PART I, Submittals paragraph under Close-out documentation.
  - 1. All Record Document information, except for full size floor plans and detail drawings, will be placed in the appropriate location in the Operations and Maintenance Manual described below.
  - 2. Full sized drawing sheets shall be supplied in triplicate and on electronic media.

#### **1.4 OPERATIONS AND MAINTENANCE MANUALS (OWNER’S MANUAL)**

- A. Prepare Operations and Maintenance Manuals in accordance with Division 1 Section “Maintenance and Operation.” In addition to the requirements specified in Division 1, provide additional information as detailed in each Section and include the following information for equipment items:
  - 1. Manufacturer’s printed operating procedures to include start-up, break-in, and routine and normal operating instructions, regulation, control stopping, shutdown, and emergency instructions.

2. Equipment Maintenance Manuals indicating routine preventative maintenance and troubleshooting, disassembly, repair, and reassembly, aligning and adjusting instructions.
- B. Schedule:
1. A review copy of the O&M Manual shall be submitted to the Owner within 2 weeks of substantial completion of the Project.
  2. The corrected reproductions of the Manual shall be submitted within 2 weeks of the return of the review copy by the Owner.
- C. Construction
1. Manuals shall be bound in hard cover, 3 ring binder(s) with clear plastic “pocket” covers to insert Project Information on the exterior of the Binder.
  2. Maximum individual Binder spine size shall be 3”; utilize multiple binders as required.
- D. Operations and Maintenance Manuals shall include the information listed below and be assembled as follows:
1. Binder shall be marked on the cover and spine with the following information
    - a) Project Information
      - 1) Title of Project
      - 2) Name and address of Owner, Contractor, and Architect/Engineer
      - 3) Completion date of Project
    - b) Contents of Binder
  2. Section 1:
    - a) Index
      - 1) Provide additional information if multiple binders are utilized.
  3. Section 2 through x (Provide one (1) Tabbed Section for each Specification Section).
    - a) Each Specification Section Tab shall include the following information:
      - 1) Sub Tab 1
        - i) Specification Section Identification
      - 2) Sub Tab 2
        - i) Warranty Information
        - ii) Copy of “Substantial Completion” Document establishing warranty period.
        - iii) Punch List Final Inspection certificate
    - 3) Sub Tab 3
      - i) A listing of all materials and equipment that was submitted for approval shall be bound into this manual separated into

- individual sections (by the Division 27 Section number) for each system.
- ii) A List of Drawings included as attachments to the O & M Manual.
    - (A) Full Size drawings shall be submitted with the Manual and a index including sheet Title and Number be placed in this Tab
- 4) Sub Tab 4
- i) A copy of the Shop Drawings “Product Information Sheets” for each item required to perform Work as specified
    - (A) Include a copy of the “stamped” and “approved” Product Information Sheets for each product utilized on the Project.
- 5) Sub Tab 5
- i) Manufacturer provided information (As Applicable)
    - (A) Installation instructions published by the manufacturer
    - (B) Operating instructions published by the manufacturer
    - (C) Maintenance Manuals furnished with the equipment
      - (1) Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and re-assembly; aligning and adjusting instructions.
      - (2) Parts list pertaining to that equipment
    - (D) Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
    - (E) Manufacturer's printed operating procedures including start-up, break-in, normal operating instructions, regulation, control, stopping, shutdown, and emergency instructions.
    - (F) Emergency operating instructions or a list of service organizations (including addresses and telephone numbers) capable of servicing various parts of the system.
- 6) Sub Tab 6
- i) Test reports (as applicable)
    - (A) Infrastructure
      - (1) Copper Backbone tests
      - (2) Fiber Optic Backbone Tests
      - (3) Horizontal cable tests
    - (B) Systems
      - (1) As required by the individual Specification Section
  - ii) Summary test reports shall be placed in the O & M manual.
    - (A) Provide an electronic copy (CD-ROM) of all test results
      - (1) Provide “Reader” software on the disk.
    - (B) Provide a single copy of each detailed test.

- (1) Tests shall be placed in (a) binder(s) in the same order as submitted on the summary reports.
    - (2) Submit with final "Approved" O & M Manual submission.
  - 7) Sub Tab 7
    - i) Items listed in individual Division 27 sections and as previously described in the Record Documents paragraph. (Additional Tabs to separate Section(s) requirements.
- E. Distribution:
  - 1. Provide one review copy for Consultant approval prior to reproduction.
    - a) Consultant will review, correct or approve, and return.
  - 2. Provide (5) copies of the complete (corrected) manual.
    - a) Include one printed copy of test results as detailed above.
    - b) Provide 5 copies of all attachments (drawings; electronic test reports, etc.).

## **PART 2 PRODUCTS**

### **2.1 NOT USED**

## **PART 3 EXECUTION**

- A. Record Documents (A.K.A. AS-BUILTS)
  - 1. Shall be prepared as outlined above.
  - 2. Record actual site specific information
    - a) Make arrangements for providing two complete sets of communication prints which shall be used to provide record drawings which shall be separate, clean, prints reserved for the purpose of showing a complete picture of the work as actually installed (including routing of all conduit and cables).
    - b) Drawings shall serve as work progress report sheets and the Contractor shall make any notations, neat and legible thereon daily as work proceeds. The drawings shall be available for inspection at all times and shall be kept at the job at a location designated by the owner's representative.
    - c) Maintain the clean, undamaged set of prints of Contract Drawings as well as a set of submittal drawings and coordination drawings where applicable. Mark the sets to show the actual installation where the installation varies from the Contract Documents as originally shown. Record drawings shall include locations of underground and concealed items if placed other than shown on the Contract Documents. Do not permanently conceal any construction until this required information is recorded. Mark which drawing is most capable of showing conditions fully and accurately. Where shop drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
    - d) Record documents shall show changes in: size, type, capacity, etc., of material device or piece of equipment, location of device or piece of

equipment; location of outlet or source of building service systems; routing of piping, conduit, or other building services. These drawings shall also record location of concealed equipment, communication service work, conduits and other piping/work by indication of measured dimensions to each line from readily identifiable and accessible walls or corners of building. Indicate all approved substitutions, contract modifications, and actual equipment and materials installed.

- e) Record documents shall include a detail diagram of all mounting devices and method of rigging those devices to the structure. Record documents shall include plan view drawings indicating cable paths, cable types identified, device identification, riser diagrams, system block diagrams and rack layouts. System block diagrams shall indicate device selection and location in signal flow schematically. Contractor shall provide legend defining all devices and symbols used.
- f) For communication work installed below slabs, pavements, grade, etc., these drawings shall also record location of nearby concealed water piping, sewers, wastes, vents, ducts, conduit and other piping, etc. by indication of measured dimensions to each line from readily identifiable and accessible walls or corners of building and from adjacent communication work. Show inverted elevation of underground communication work relative to work installed by other trades.
- g) Upon substantial completion of the work make arrangements for obtaining a complete set of CAD computer files for the project. All information from the print record drawings shall be neatly drafted/digitized (using pre-established layering system) into the applicable CAD drawing. Neatly erase and redraft work as required to reflect the work as actually installed. Perform drafting in a manner in which all work shall be shown in its actual locations, existing as well as new, by erasing inaccurate locations and redrawing proper routing/locations. This applies for all concealed work as well as work visible. All work shall be performed using AutoCAD Release 2000 or more recent release of AutoCAD.
- h) Affix near the title block on each drawing of the set of record drawing prints the Contractor's Company Names, signature of Contractors' Representative and current date. Deliver one set of prints to the Designer. Deliver the second set of prints, the original reproducibles, the CAD computer files and the marked-up field prints to the architect.
- i) All prints shall be signed and dated by the General Contractor, This Contractor and applicable Subcontractor.
- j) In addition to the above, provide "as-built" record documentation for shop drawings (and coordination drawings where applicable).

**END OF SECTION 27 01 00.00**

## **BASIC MATERIALS AND METHODS FOR COMMUNICATIONS**

### **PART 1 MATERIALS AND METHODS**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Basic materials, methods and installation guidelines applicable to the installation of all communication systems.
    - a) This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
- B. Related Sections
  - 1. All Division 27 Sections.
- C. Related Drawings
  - 1. All Technology (T-Series) Drawings

#### **1.3 QUALITY ASSURANCE**

- A. Welding
  - 1. Welding shall be performed by persons licensed by the authority having jurisdiction where the work is performed. This shall apply to all work which is routinely regulated by said authority.
- B. High Voltage Wiring
  - 1. High voltage wiring and connections shall be performed by persons licensed by the authority having jurisdiction where the work is performed. This shall apply to all work which is routinely regulated by same authority.

### **PART 2 PRODUCTS**

#### **2.1 NOT USED**

### **PART 3 EXECUTION**

### 3.1 RELATED OPERATIONS

#### A. Welding

1. Onsite welding, where it is necessary, shall not be performed without the express written consent of the owner's representative. All project specifications governing welding shall apply, regardless of whether said specifications are referenced within the Division 27 specifications.

#### B. High Voltage Wiring

1. Review all high voltage provisions for This Contractor's work with the Division 16 electrical contractor. Coordinate specific device termination, loading and circuiting requirements with the electrical contractor.

### 3.2 INSTALLATION OF COMMUNICATIONS SYSTEMS

#### A. General

1. All work installed in finished areas shall be concealed. All work installed in unfinished areas may be exposed at the discretion of the Owner's representative.
2. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, Any exceptions to be approved by Owner.
3. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.
4. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
5. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
6. Verify all dimensions by field measurements. Take measurements and be responsible for exact size and locations of all openings required for the installation of work. Figured dimensions are reasonably accurate and should govern in setting out work. Where detailed method of installation is not indicated or where variations exist between described work and approved practice, direction of the owner's representative on job shall be followed.
7. The symbols used to indicate the purpose of which the various outlets are intended are identified in the Legend.
8. If during construction it becomes apparent that certain minor changes in layout will affect a neater job or better arrangement, such alterations shall be made as part of the contract. Owner's review shall be obtained before making such changes.
9. Workmanship throughout shall conform to the standards of best practice. Marks, dents or finish scratches will not be permitted on any exposed materials, fixtures or fittings. Inside of panels and equipment boxes shall be left clean.
10. Use caution not to exceed the allowed bending radius for respective cables and not to compromise the integrity of the cables during installation by pulling cable management devices too tightly, damaging cables, etc. Raceway/Cabling bending

radii shall be minimum as directed by cable manufacturer. Use pulling compound or lubricant, where necessary; compound must not deteriorate conductor or insulation.

B. Cable

1. General

- a) Provide color-coded jackets to identify runs of different systems.
  - 1) See related specifications and drawings for applicable color coding.
- b) Neatly route cables parallel, perpendicular and plumb to building architectural lines.
- c) **Neatly comb out multiple cable bundled runs to remove tangling and crossing of cables within the bundles. Neatly dress all cable work and provide vertical and horizontal cable management** (or other approved method) for properly dressing all work at racks, control panels, backboards etc. See detail(s) if applicable.
  - 1) To avoid Alien Crosstalk, do not cinch UTP cables into tight bundles.
- d) Plenum-rated hook and loop one inch wide tape shall be used wherever wire ties are permitted and wherever plenum rated cable is used.
- e) Plenum-rated hook and loop one inch wide tape shall never be used in a manner that causes deformation of the cable jacket, damage to the cable, or has any adverse affect on the usability, specifications or longevity of the cable(s) on which it is applied.
- f) Plenum-rated hook and loop one inch wide tape (Velcro) type wire ties shall be used in plenum spaces; in equipment racks; in rack cabinets, and; in related equipment housing enclosures.

2. Support

- a) All cables shall be supported/anchored every 5 feet (or less) and within 12" of device boxes, outlets, racks/cabinets and cable tray.
- b) Use J-Hook type cable supports for all cables run outside of conduit or cable tray. Bridle rings shall not be used for Communications Technology cables.
- c) Use separate J-Hook cable support systems for cables belonging to different systems and for cables carrying different operating levels. See Cable Separation guidelines in this section.
- d) Loosely secure cables at each J-Hook.
- e) Cables shall not be directly or indirectly supported by a suspended ceiling or any other surface, support, material or structure not permissible for this use by all applicable codes and standards.
- f) Cable trays or messenger strand positioning
  - 1) Used to route cables in hallways

- 2) Each must have a minimum twelve inches (12") vertical clear space above the top of the cable tray or messenger strand, and a minimum six inches (6") clear space below and on each side of the cable tray or messenger strand.

### 3. Cable Separation

- a) Cables carrying signals of different nominal operating level shall be kept separated to reduce the risk of undesirable cross-talk interference between cables.
  - 1) As a general rule, for each 25dB of nominal level voltage difference between cables, Contractor shall provide an additional 6 inches of physical separation between the cables. For example: cables with a 25dB voltage difference shall be separated by at least 18 inches. As the difference increases the distance shall increase proportionally.
  - 2) This guideline shall be used to govern the separation of low voltage Communications Technology cabling from AC power circuits as well. For example: A Microphone line running parallel to a 480v power line shall be separated by nearly 27-30 inches.
  - 3) Provide greater separation than this guideline where the contractor believes and/or determines it is necessary to prevent or remedy interference between cables.
- b) Keep length of parallel runs to a minimum. Cross cables of different nominal levels at 90 degrees.
- c) Provide additional separation as necessary to prevent and remedy any crosstalk which:
  - 1) Adversely affects the performance and usability of the system, or;
  - 2) Exceeds specific crosstalk performance specified in individual specifications.
- d) Contractor shall take all precautions necessary to keep low-voltage cable away from sources of EMI and RF interference. Where close proximity is absolutely necessary to satisfactory appearance, performance or installation of the Work, provide all necessary shielding necessary to ensure that ingress interference is minimal and has no negative impact of the Work.

### 4. Cable Termination

- a) The cables terminating at a device outlet shall be left not less than 10 inches to facilitate installation and servicing of devices. Longer working lengths shall be provided as appropriate to the application.
- b) All termination types shall correctly match the cable and device termination point. Connectors of the appropriate type, size, color and rating shall be used to match with the mating equipment
- c) Tools as recommended by each specific connector manufacturer shall be used in attachment of all connectors.
- d) Spade connectors.

- 1) Spade type connectors shall be used on cable ends where screw-type terminal connectors are used.
    - i) All spade connectors shall be insulated. Provide heat shrink type insulation where solder-type or non-insulated spade connectors are used.
  - 2) Spade connectors used shall be rated by the manufacturer for the gauge, insulation, type and stranding of the cable to which it is applied. Spade connectors shall be sized to exactly match the stud size and spacing of mating termination connector.
  - 3) Tools as recommended by the specific connector manufacturer shall be used in attachment of the connector to the cable.
  - 4) When spade connectors are the required to be used for audio circuits operating at  $\leq +8\text{dBv}$  nominal, solder type spade connectors only shall be permitted.
  - 5) No more than two spade connectors shall be permitted under a single terminal. Fewer should be used when recommended by the specific manufacturer's equipment or connector.
- e) Wire Nuts
- 1) Wire nuts shall not be used in any audio circuit, except when necessary in the following:
    - i) 25 Voltage Constant-Voltage loudspeaker circuits.
    - ii) 70 Voltage Constant-Voltage loudspeaker circuits.
  - 2) Wire nuts shall not be used in any data or voice communications or remote control circuit.
  - 3) Wire nuts shall not be used in any circuit which radiates RF energy.
  - 4) Contractor must advise and gain prior approval of the Owner for any circuit which the Contractor desires to use wirenuts as the means of termination.
- f) Drain Wires, Non-insulated Ground Wires and Shields
- 1) Drain or non-insulated ground conductors shall be insulated with appropriately sized heat-shrinkable insulated sleeving immediately upon exit from the jacket of the cable. Contractor shall use GREEN colored sleeving unless otherwise necessary to resolve specific color coding conflicts on a given cable. This methodology shall apply to ALL methods of termination, including inline connectors, device plates, direct equipment terminations etc... Sleeving shall be applied to twisted and braided shields once the internal conductors have been combed out or otherwise removed from the center of the shield.
  - 2) Wherever a cable contains a non-insulated conductor within a jacketed cable, the conductors, as they exit the manufacturer's jacket, shall have a piece of heat shrinkable sleeving applied equally over the jacket and the exposed insulated conductors. The length of this sleeving shall be 1" for all cable diameters of .250" or less. For cables diameters larger

then .250" the length of the sleeving shall be approximately equal to 4 times the diameter of the cable jacket. Note: This added sleeving is recommended but not mandatory when cable termination occurs fully within the confines of a fully insulated and strain relieved connector. Black shall be used unless otherwise necessary for specific cosmetic or cable identification purposes.

- 3) A heat-gun of the appropriate temperature, size, type and rating for shrinking the tubing shall be used as recommended by the manufacturer of the sleeving used. Open flame (i.e. matches, cigarette lighters, torches) and direct metal conduction (i.e. soldering iron) methods to shrink the sleeving shall not be permitted. Sleeving which is burnt or otherwise marred shall be removed and replaced.
- 4) There shall not be any non-insulated exposed conductors within a device backbox, junction box, or equipment rack/cabinet.

g) Unused Conductors

- 1) Unused conductors shall not be "clipped" or removed from any jacketed cable. Conductors which are not required or used at the end of a jacketed cable shall be kept intact. Conductors shall be fully insulated from one and other to prevent shorts which could occur at either end of the cable. Conductor ends shall also be insulated to prevent shorts to other conductive materials which could come in contact with the conductor.
- 2) Unused conductors shall be kept the same length as the longest conductor of the cable being used.

h) Cable and Conductor Nicks

- 1) Attention shall be paid to the proper preparation of all cables and all conductors of these cables. There shall not be nicks to cable jackets, conductor insulation, or the conductors themselves.
- 2) Special attention should be paid to nicked conductors. Should a conductor be nicked during preparation or termination the cable shall be reworked/replaced to remove the nick.

i) Cut, Disconnected, or Not Terminated Cables

- 1) Any voice, data, or coaxial cable that is cut, disconnected, or not terminated at both ends shall be completely removed end to end. Any labels at either end shall be erased. Record drawings shall reflect the removal of these cables.

**END OF SECTION 27 05 01.00**

## **GROUNDING AND BONDING FOR COMMUNICATION SYSTEMS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

- 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:

- 1. Grounding and Bonding requirements for Communication Systems
    - a) This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
  - 2. System includes but is not limited to:
    - a) Copper Conductors.
    - b) Busbars
    - c) Termination devices
    - d) Hardware
    - e) Labels

- B. Related Sections

- 1. All Division 27 Sections

- C. Related Drawings

- 1. Technology (T-Series) Drawings

#### **1.3 REFERENCES:**

- A. NFPA Compliance:

- 1. Components and installation shall comply with NFPA 70, “National Electrical Code” (NEC).

- B. UL compliance:

- 1. Comply with UL 467, “Grounding and Bonding Equipment.”

- C. NFPA National Electric Code Article 250, “Grounding.”

- D. Available reference sources:

- 1. Latest Version of Green and Emerald books.

- E. ANSI/TIA/EIA-J-STD-607A, “Commercial Building Grounding and Bonding Requirements for Telecommunications.”

- F. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### **1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK**

- A. Provide, install, and test a complete grounding system for the Communications infrastructure and systems specified in related sections and depicted on the drawings.
  - 1. Communications infrastructure components will achieve a common ground with the Building's grounding electrode system.
  - 2. Reference the Grounding and Bonding Diagram(s) in the related drawings for a schematic of the required connectivity.
    - a) At minimum, the grounding system shall bond together all racks/cabinets, tray, ladder rack, and risers in each wiring closet (ER and TR). Bond each TR to the grounding electrode system and to the ER. Bond the resulting grounding system to the grounding electrode system and the Electrical grounding system at the main building ground point. Bond any additional points indicated in the drawings.
    - b) Label and document the entire system as described in Part 3.
- B. System shall be thoroughly coordinated with Division 26 Electrical Contractor.
  - 1. See Grounding Diagram for basic division of responsibility.

## 1.5 SUBMITTALS

- A. General
  - 1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
  - 2. Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Items to be submitted for approval prior to commencement of work:
  - 1. Product Data
    - a) Manufacture datasheets for all system equipment
    - b) Manufacture datasheets for all cable
    - c) Manufacture datasheets for all connectors
      - 1) Data sheets shall include
        - i) Manufacturer name
        - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
        - iii) Manufacturer product description
        - iv) Paragraph number of this section where the product is specified.
        - v) Picture or Drawing of item
  - 2. Shop Drawings
    - a) System block wiring diagram, detailed.
  - 3. Quality Assurance / Control Submittals
    - a) RCDD Certification for the staff member responsible for this project.
    - b) Resume of the last 10 projects of the RCDD responsible for this project
    - c) BICSI Technician's certificate for each lead Technician(s) on the project
- C. Closeout Submittal (To be included in O & M Manual)

1. Prepare and submit a Ground System connectivity diagram
  - a) Indicate all connectivity points between system components, between system components and items being grounded, and between system components and building/electrical ground points.

## **PART 2 PRODUCTS**

### **2.1 PRODUCT STANDARDS**

#### **A. General**

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.

### **2.2 GROUNDING AND BONDING BUSBARS**

#### **A. Telecommunications Main Grounding Busbar (TMGB):**

1. Electro-tin plated 1/4" thick copper bar
2. Insulated stand-offs
3. 19 pairs of 5/16" holes and 3 pair of 7/16" holes
4. 4 inches high x 15.5 inches wide
5. Standard of quality shall be Erico Electrical Products TMGB-A16L19PT.
  - a) Additional approved manufacturers: Chatsworth, Panduit.

#### **B. Telecommunications Grounding Busbar (TGB):**

1. Electro-tin plated 1/4" thick copper bar
2. Insulated stand-offs
3. 8 pairs of 5/16" holes and 3 pair of 7/16" holes
4. 2 inches high x 15.5 inches wide
5. Standard of quality shall be Erico Electrical Products TGB-A16L08PT.
  - a) Additional approved manufacturers: Chatsworth, Panduit.

### **2.3 BONDING CONDUCTORS**

- A. All bonding conductors shall be green insulated copper. Unless otherwise specified, size conductors as required by NEC.
- B. The BC shall be a minimum # 4 AWG.
- C. The TBBC and TEBC shall be a minimum # 6 AWG.
- D. TBBIBC shall be minimum # 8 AWG.

### **2.4 CONDUCTOR TERMINATIONS**

- A. Two hole compression lugs:

1. Two Hole Lugs Long Barrel Type with window.
  - a) Shall meet J-STD-607-A requirements for network systems ground.
  - b) Shall be Tin plated copper
  - c) Inspection window to assure conductor insertion
  - d) NEMA hole sizes and spacing
  - e) Coded on barrel for correct die selection
  - f) Standard of quality shall be Panduit LCC series
    - 1) Additional approved manufacturer(s):
      - i) Erico Electrical Prouducts
      - ii) Thomas and Betts
      - iii) Burndy

B. Hardware

1. Paint Piercing Grounding Washer Kit
  - a) Color coded Green
  - b) Penetrates painted surfaces to provide electrical connection
  - c) Shall be supplied with antioxidant compound
  - d) Standard of Quality shall be Panduit RGW Series
    - 1) Additional approved manufacturer(s):
      - i) Erico Electrical Prouducts
      - ii) Thomas and Betts
      - iii) Burndy
2. Thread Forming Bonding Screws
  - a) Shall be Black
  - b) Penetrates painted surfaces to provide electrical connection
  - c) Shall have "Phillips" head
  - d) Standard of Quality shall be Panduit RGTBS Series
    - 1) Additional approved manufacturer(s):
      - i) Erico Electrical Prouducts
      - ii) Thomas and Betts
      - iii) Burndy

C. Conductor Taps

1. "H" style conductor taps
  - a) Slotted design

- b) Matching clear covers to meet UL 94V-0 flame retardancy
- c) UL and CSA rated up to 600v
- d) Standard of Quality shall be Panduit HTWC Series
  - 1) Additional approved manufacturer(s):
    - i) Erico Electrical Products
    - ii) Thomas and Betts
    - iii) Burndy

## 2.5 LABELS

### A. Caution Label

- 1. Shall read:

**IF THIS CONNECTOR OR CABLE IS  
LOOSE OR MUST BE REMOVED  
PLEASE CALL THE BUILDING  
TELECOMMUNICATIONS MANAGER**

- a) Standard of Quality Shall be Panduit LTYK
  - 1) Additional approved Manufacturers: Brady, Hellerman/Tyton

## PART 3 EXECUTION

### 3.1 INSTALLATION

- A. Work shall be installed in accordance with these specifications and related Drawings and all manufacturers recommended installation practices.
- B. Ground electrical systems and equipment as required by code, utility, local ordinances, and requirements herein.
- C. Bonding conductors shall be continuous and routed in a direct path to the point of termination.
- D. All grounding busbars shall be isolated from the structure support by a 2 inch minimum separation using manufacturer's recommended insulating stand-offs and hardware.
- E. Clean grounding busbars before terminating conductors.
- F. Installation details:
  - 1. Install copper bus bar on the plywood backboard.
  - 2. Install Green (minimum) #4 AWG insulated copper grounding conductor from main building grounding electrode system at service entrance to ground bus at the Entrance Facility.
  - 3. Install Green (minimum) #6 AWG insulated copper grounding conductor(s) from the ER ground bus to each "TR" ground bus.
    - a) Where required by code, conductors shall be installed in continuous EMT conduit.

- b) Install grounding bushings on conduit and bond, using Green minimum #12 AWG wire, at both ends. Paint all conduit fittings, junction boxes and covers "GREEN".
- 4. Install Green (minimum) #8 AWG bonding jumper (12" max) with appropriate lugs at each cable tray joint or install manufactured braided copper grounding jumper equal to B-Line #CAM-GJ, T&B #BD12, OZ/Gedney type "FB" or Mono-Systems.
- 5. Install Green (minimum) #8 AWG grounding conductor with appropriate lugs from side of cable tray down to ground bus bar. Drill # tap side of cable tray (for appropriate size bolt, 1/4" x 20 min.), making sure that bolt does not extend into wire management part of tray.

### 3.2 LABELING

- A. Label the ends of all conductors as indicated and as shown on the Drawings.
  - 1. Label the TEBCs consecutively within each closet TEBC-01 through TEBC-xx with "xx" representing the last number in order.
- B. Label all TGBs and the TMGB as identified on the Drawings and with the following:

**IF THIS CONNECTOR OR CABLE IS  
LOOSE OR MUST BE REMOVED  
PLEASE CALL THE BUILDING  
TELECOMMUNICATIONS MANAGER**

### 3.3 CONNECTIONS

- A. Bond the TMGB to the service equipment (power) ground, typically located in the electrical entrance facility, using the most direct route possible to minimize conductor length.
- B. Bond all TGBs to the TMGB using specified conductor.
- C. Whenever two or more TBBs are used in a multi-story building, bond them together on the top floor and at every third floor, at a minimum, with a TBBIBC.
- D. Bond the following to the TMGB when present:
  - 1. Telecommunications panel board:
    - a) Alternating Current Equipment Ground Bus (ACEG), if equipped, or its enclosure.
  - 2. Building structural steel, if exposed. (Steel rebars of reinforced concrete are not required to be bonded.)
  - 3. Metallic equipment racks.
  - 4. Cable shields.
  - 5. All metal raceways and cable trays for telecommunications cabling extending from the same room or space where the TMGB is located.
  - 6. Floor tile ground tab if provided.
  - 7. Others as identified on the Drawings.

E. Bond the following to the TGB when present:

1. Telecommunications panelboard: Alternating Current Equipment Ground Bus (ACEG), if equipped, or its enclosure.
2. Building structural steel, if exposed. (Steel rebars of reinforced concrete are not required to be bonded.)
3. TGBs within the same space if provided.
4. TBBs terminated on the same floor to other TGBs.
5. Metallic equipment racks.
6. Cable shields.
7. All metal raceways and cable trays for telecommunications cabling extending from the same room or space where the TMGB is located.
8. Floor tile ground tab if provided.
9. Others as identified on the Drawings.

F. Terminate BC and TBB conductors with two-hole compression lugs.

G. Terminate TEBC conductors with two-hole compression lugs.

### 3.4 BONDING

A. General:

1. Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
2. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
3. Make connections with clean bare metal at points of contact.
  - a) Utilize Bonding screws and Paint piercing Grounding washer Kits to attach painted surfaces.
4. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.
5. Utilize H-Tap compression fittings with clear insulating covers to tap cables.

B. Exothermic welded connections:

1. Use for connections to structural steel and for underground connections except those at test wells. Install at connections to ground rods. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Tightening:

1. Tighten grounding and bonding connectors and terminals in accordance with the manufacturer's published tightening methods and practices. Where manufacturer's requirements are not indicated, tighten connections to comply with UL 486A and UL 486.

D. Compression-type connections:

1. Use hydraulic compression tools to provide the correct circumferential pressure for compression connectors. Use tools and dies recommended by the manufacturer of the connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on the ground conductor.
- E. Moisture protection:
1. Where insulated ground conductors are connected to ground rods, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

**END OF SECTION 27 05 26.00**

## TEST RESULTS DATA SHEET

Project Name: \_\_\_\_\_ Crew Members: \_\_\_\_\_

Test Date: \_\_\_\_\_

Tester Used: \_\_\_\_\_ Current (High\Low) \_\_\_\_\_

Serial Number: \_\_\_\_\_ Filter (On\Off) \_\_\_\_\_

Frequency (Hz) \_\_\_\_\_

TGB Identification: \_\_\_\_\_

Reference Test Resistance: \_\_\_\_\_  $\Omega$

Ground Reference System Continuity Test Data					
TGB		TGB with Panelboard Ground		TGB with Panelboard and Building Steel Ground	
Reference	Test (Difference)	Reference	Test (Difference)	Reference	Test (Difference)
$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$	$\Omega$

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## **PATHWAYS FOR COMMUNICATIONS SYSTEMS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

##### **A. Section Includes:**

- 1. This Section includes requirements and minimum standards for:
  - a) Raceways
  - b) Fittings
  - c) Boxes
  - d) Penetrations
  - e) Pathway accessories
- 2. This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
- 3. This Section requires the addition of basic items, not specified elsewhere, to the installation of pathways.
  - a) Add the following to the pathways:
    - 1) Provide a pull rope in each installed pathway and leave a pull rope in the pathway after the cabling is installed.
    - 2) Provide proper identification, labeling, and documentation of key pathway locations and components.
    - 3) All pathways designed for fiber optic cables will require an innerduct for the installation of the fiber optic cable unless interlocking armored cable construction is utilized.
    - 4) Provide cable spillways where cabling will drop out of sleeve(s), unsupported for more than six inches:

##### **B. Related Sections**

- 1. All Division 27 Sections

##### **C. Related Drawings**

- 1. Technology (T-Series) Drawings

#### **1.3 REFERENCES**

- A. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- B. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.

- C. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 GENERAL INFORMATION

- A. NFPA Compliance:
  - 1. Comply with NFPA 70 “National Electrical Code” for components and installation.
- B. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access.
- C. UL Compliance:
  - 1. Cable tray shall be UL certified.
  - 2. Sleeves shall be UL listed assemblies.
- D. All Work shall fully comply with these Specifications and related Drawings and all manufacturers’ recommended installation practices.

#### 1.5 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. The work covered by this Specification Section includes any and all requirements for this type work required for proper installation of work specified in each related Division 27 Specification Section and/or as shown on the Drawings.
  - 1. This Specification Section is a Materials and Methods Section for Division 27. All requirements herein are required by each related Section and will be enforced for each related Section.
  - 2. Provide Pathways for Communications to create a re-usable and accessible pathway for Communications cables. Communications cabling cannot be visible. Provide pathways as indicated to conceal all communications cabling from view as well as from paint.

#### 1.6 SUBMITTALS

- A. General
  - 1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.  
Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Items to be submitted for approval prior to commencement of work:
  - 1. Product Data
    - a) Manufacture datasheets for all items
      - 1) Data sheets shall include
        - i) Manufacturer name
        - ii) Manufacturer model number (as it appears on manufacturer’s product data sheet)
        - iii) Manufacturer product description
        - iv) Paragraph number of this section where the product is specified.

- v) Picture or Drawing of item

## **PART 2 PRODUCTS**

### **2.1 PRODUCT STANDARDS**

#### **A. General**

1. Part II is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
  - a) This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the “Products” section that are not required under the Scope of this Contract.

### **2.2 RACEWAYS**

#### **A. Conduits**

1. Rigid steel conduit:
  - a) Threaded rigid steel conduit shall be manufactured from mild steel, zinc galvanized both inside and outside including threads. It shall be constructed in accordance with ANSI C80.1, Federal Specification WW-C-581; UL listed.
2. Intermediate metallic conduit:
  - a) Threaded intermediate metallic conduit shall be manufactured from mild steel, zinc galvanized both inside and outside including threads. It shall be constructed in accordance with ANSI C80.6, Federal Specification WW-C-581; UL listed.
3. Electric metallic tubing:
  - a) Electric metallic tubing shall be manufactured from mild steel, zinc galvanized both inside and outside. It shall be constructed in accordance with ANSI C80.2, Federal Specification WW-C-563; UL listed.
4. Flexible metallic conduit:
  - a) Flexible metallic conduit with neoprene jacket shall be spirally wound steel, strip zinc galvanized both inside and outside, integral ground conductor.
    - 1) Unless otherwise indicated, flexible metallic conduit provided for telecommunications cabling can only be provided as a pathway from the telecommunications outlet box to the ceiling space above and cannot exceed 6 meters.
5. Non-metallic raceways
  - a) Polyvinylchloride (PVC):
    - 1) PVC conduit shall be virgin C300 type, Schedule 40 or 80 (90° C). It shall be constructed in accordance with NEMA TC2 and Federal Specifications W-C-1094A.

#### **B. Surface raceways:**

1. Single compartment raceway:

- a) Single compartment electrical ivory raceway as indicated, surface mounted base with cover.
  - 1) Provide appropriate elbows (Panduit RAFC10IW-X), tees (Panduit TFC10IW-X), entrance end fitting (Panduit DCEFXIW-X), etc. to follow wall layout.
  - 2) Standard of quality shall be Panduit Panway LDP-10IW8-A.
  - 3) Additional approved manufacturers: Wiremold, Hubbell
- 2. Large Single compartment raceway:
  - a) Single compartment electrical ivory raceway as indicated, two piece surface mounted with snap on cover.
    - 1) Provide appropriate elbows, tees, entrance end fitting, etc. to follow wall layout. Provide wire T45WR-X retainers at a minimum of every three feet and as necessary to contain cabling.
    - 2) Standard of quality shall be Panduit Panway T-45.
      - i) Additional approved manufacturers: Wiremold, Hubbell
- 3. Two compartment raceway:
  - a) Dual channel electrical ivory raceway as shown on the Drawings, two-piece surface mounted with snap on cover, compartment for power, and compartment for data.
    - 1) Provide appropriate elbows, tees, entrance end fittings, etc. as recommended by the manufacturer.
    - 2) Standard of quality shall be Panduit Panway Twin-70.
      - i) Additional approved manufacturers: Wiremold, Hubbell
- C. Telecommunications/power poles:
  - 1. Construction:
    - a) Two compartment.
    - b) 10 foot – 5 inch height and 2 ½ inches x 2 5/16 inch overall width.
    - c) Removable covers.
  - 2. Provide mounting hardware, entrance end fitting, and ceiling trim plate.
  - 3. Standard of quality shall be Panduit Pan-pole.
    - a) Additional approved manufacturer: Wiremold, Hubbell
- D. Cable tray:
  - 1. Wall Mounted
    - a) Provide cable tray sized and located as indicated on the Drawings.
    - b) Cable tray shall comply with NEMA 8B, 12B, or 12C. Cable tray and all fittings and accessories shall effect a complete structural system in the form of a rigid mechanical tray of compatible material and design, functional to support all cabling.
    - c) Provide aluminum, rectangular tube, center spine with rungs perpendicular to the spine and spaced 6 inches on center.
    - d) Prefabricated structure consisting of a longitudinal rail with transversely connected members (rungs) that project from one side; single or double tiered; aluminum alloy.

- e) Provide gray-colored manufacturer's rung caps on all rungs.
  - f) Sections to be joined by bolted splice connectors.
  - g) 4 inches overall depth per tier, 6 inches rung spacing.
  - h) Rung ends shall be factory bent upward to a height as indicated on the Drawings.
  - i) The rungs shall be positioned at the side of the spine at the top such that the spine is not part of the cable laying area (for example see Mono-Systems "top rung" cable tray).
  - j) Provide all manufacturer recommended fittings and accessories for a complete and functional system as indicated.
    - 1) Accessories: Provide crosses, tees, angles, wyes, drops, rises, etc., and other accessories required for the installation specified.
  - k) Standard of quality shall be Mono Systems 6114-0323 and 9114-0323.
    - 1) Approved manufacturers include: Allied Support Systems, B-Line.
2. Center Hung
- a) Provide cable tray sized and located as indicated on the Drawings.
  - b) Cable tray shall comply with NEMA 8B, 12B, or 12C. Cable tray and all fittings and accessories shall effect a complete structural system in the form of a rigid mechanical tray of compatible material and design, functional to support all cabling.
  - c) Provide aluminum, rectangular tube, center spine with rungs perpendicular to the spine and spaced 6 inches on center.
  - d) Prefabricated structure consisting of a longitudinal rail with transversely connected members (rungs) that project from both sides; aluminum alloy.
  - e) Provide gray-colored manufacturer's rung caps on all rungs.
  - f) Sections to be joined by bolted splice connectors.
  - g) 4 inches overall depth per tier, 6 inches rung spacing.
  - h) Rung ends shall be factory bent upward to a height as indicated on the Drawings.
  - i) The rungs shall be positioned at the side of the spine at the top such that the spine is not part of the cable laying area (for example see Mono-Systems "top rung" cable tray).
  - j) Provide all manufacturer recommended fittings and accessories for a complete and functional system as indicated.
    - 1) Accessories: Provide crosses, tees, angles, wyes, drops, rises, etc., and other accessories required for the installation specified.
    - 2) Provide waterfall fittings in every location that cable is designed to exit the tray downward at the end of a run or between the rungs.
    - 3) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
  - k) Standard of quality shall be Mono Systems .
    - 1) Additional approved manufacturers include: Allied Support Systems, B-Line.

- 2) Approved manufacturers include: Allied Support Systems, B-Line.
3. Center-Hung RaceTray
  - a) Provide metal cable trays, of types, and sizes indicated; with splice connectors, bolts and, nuts for connecting straight lengths and fittings. Cable tray to be constructed with rounded edges free of burrs. Cable tray to be installed and supported according to NEMA standards.
  - b) Center-hung RaceTray shall be constructed of an inner wall, which provides two functions: the upper portion of the wall for anchoring the tray section, and the lower portion of the wall is designed to carry the tensile and compressive loads coming from the tray floor section to the hanger points.
  - c) A tray floor section extends equally from the center of the tray. Below this floor section, and inclining upward from the center of the tray to the end of the floor section, is another wall that forms a stiffening truss-like shape.
  - d) An outer wall extends up equally from the ends of the floor section, completing the U-shape of the tray.
  - e) Center-hung RaceTray dimensions shall be: Straight section lengths 5 feet and 10 feet ; Loading height of 6 inches; Widths shall be 9 inches.
  - f) Standard of quality shall be Mono Systems RaceTray.
  - g) Additional approved manufacturers include: Allied Support Systems, B-Line.
  - h) Provide complete to accommodate support of all communications cabling in primary pathways as indicated on the drawings.
- E. Telecommunications cabling support: Where necessary, provide additional cable support to create a re-usable pathway for Communications cables:
  1. General
    - a) Primary pathways are those supporting the cabling infrastructure from the Equipment Rooms/Telecommunications Rooms through the corridors and chases to the secondary pathways.
    - b) Secondary pathways are those supporting the cabling infrastructure from the primary pathway to telecommunications outlets.
    - c) Cable supporting devices manufactured with small round surfaces (i.e. bridal rings) are not acceptable.
  2. Primary pathways
    - a) Messenger Strand
      - 1) Anchors shall be securely mounted to building structure at each end.
      - 2) Tensioners shall be installed to connect strand.
      - 3) Additional supports shall be installed with threaded rod from the deck above to support the strand approximately 6-8" above suspended ceiling in all locations.
        - i) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
        - ii) Properly sized.

- (A) Multiples of strands (100 horizontal cables each) appropriate to handle the required cable quantities plus 25% spare capacity.
    - (B) Separate strand for Backbone cables.
  - iii) Provide minimum 1/4" steel strand with applicable hardware.
- b) Open top cable supports
  - 1) Plenum rated
  - 2) Complies with UL, cUL, NEC, and ANSI/TIA/EIA requirements for structured cabling systems.
  - 3) Shall be mounted to building structure or suspended by threaded rod from the deck above approximately 6-12" above suspended ceiling.
    - i) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
    - ii) Properly sized.
      - (A) Multiples of J-Hooks (80 cables each) appropriate to handle the required cable quantities plus 25% spare capacity.
      - (B) Multiples of J-Hooks (300 cables each) appropriate to handle the required cable quantities plus 25% spare capacity.
    - iii) Provide Erico CAT32/CAT64 or approved equal for all primary pathway cable support.
    - iv) Additional approved manufacturers: B-Line, Panduit
- 3. Secondary pathways (those extending from the primary pathways to the space above the telecommunications outlets).
  - a) J-hooks with galvanized finish to provide smooth surface and corrosion resistance.
  - b) Complies with UL, cUL, NEC, and ANSI/TIA/EIA requirements for structured cabling systems.
  - c) Accommodates up to 16 horizontal UTP cables.
  - d) Shall be mounted to building structure or suspended by threaded rod from the deck above approximately 6-12" above suspended ceiling.
    - 1) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
  - e) Standard of Quality shall be Erico CAT12xx/CAT21xx
    - 1) Additional approved manufacturer(s): B-Line, Panduit
- 4. Small Secondary pathways
  - a) Mounting for up to ten 4 pair UTP cables may be supported from ceiling grid support wires (at least every 5').
  - b) Standard of quality shall be Erico CAT12TS
    - 1) Additional approved manufacturer(s): B-line, Panduit

## 2.3 FITTINGS

### A. Rigid steel or intermediate metallic conduit:

- 1. Fittings shall be threaded zinc galvanized steel.

2. At least one bushing shall be grounding type
    - a) Equipped with a ground lug
    - b) Provide on each conduit or sleeve where surface extends below ceiling line.
  - B. Electric metallic tubing:
    1. Fittings shall be compression type.
    2. At least one bushing shall be grounding type
      - a) Equipped with a ground lug
      - b) Provide on each conduit or sleeve where surface extends below ceiling line.
  - C. Flexible metallic conduit:
    1. Fittings shall be suitable for the specific application.
    2. Use oil-tight fittings with neoprene jacketed flexible metallic conduit.
  - D. Non-metallic conduit:
    1. Fittings shall be of the same type and manufacturer as the raceway, connected in accordance with manufacturer's written instructions.
  - E. Expansion:
    1. Expansion fittings shall be of a type suitable for the particular condition and shall be complete with bonding jumper.
- 2.4 BOXES
- A. Box Eliminator devices
    1. Standard outlet size brackets that securely clamp to drywall.
    2. Available in single and dual gang sizes.
    3. Standard of quality shall be Caddy by Erico MP-1
      - a) Additional approved manufacturer(s):
  - B. Floor Boxes
    1. Shall be utilize only with prior Owner approval
    2. FSR type boxes; see Division 26 specifications for exact sizing.
    3. Separate Telecommunications and Electrical compartments.
    4. A minimum of two 1" conduits or a 1 1/4" conduit for Communications cables.
  - C. Outlet boxes:
    1. General:
      - a) Stamped steel, code gauge, galvanized, minimum 2 1/2 inches deep.
      - b) Provide single or double gang outlet boxes as indicated in details on the Drawings.
    2. In masonry or tile walls:
      - a) Rectangular boxes, 4" square, with square corners minimum 2 1/2 inches deep where the box is at the end of the run.
        - 1) Provide 1" deep single or 2 device trim ring.

- b) Rectangular boxes, 4 11/16" square, with square corners minimum 2 1/2 inches deep where the box is in a continuing run.
    - 1) Provide 1" deep single or 2 device trim ring.
- 3. In gypsum board walls
  - a) Single and dual gang outlet boxes with a depth of 3 to 3.5".
- 4. Surface mounted and exterior use:
  - a) Single or dual gang Cast aluminum boxes with threaded hubs
- 5. No through-wall boxes or utility boxes will be accepted.
- 6. Where surface raceway is indicated, provide outlet boxes designed for use with the raceway by the same manufacturer as the surface raceway.
- D. Junction boxes:
  - 1. Covers shall be screw attached (unless otherwise noted on the drawing) and of same type of material as the box. All covers shall be easily accessed.
  - 2. Boxes in exterior or moist locations shall meet NEMA 3R (at minimum)
    - a) The box must meet the NEMA requirements for the atmospheric condition in which the box is installed.
  - 3. Surface raceway boxes
    - a) Where surface raceway is indicated, provide junction boxes by the same manufacturer as the surface raceway.
- E. Pull boxes:
  - 1. Required after every 100' or after 180 degrees of bends in a conduit run
  - 2. Shall be sized as follows:
    - a) One 4" conduit straight through pull:
      - i) 15" wide, 60" long, and 8" deep; minimum.
      - ii) Add 8" to the width for each additional conduit.
      - iii) Information about other trade sizes; reference EIA/TIA 569 standard.
- F. Splice boxes:
  - 1. Required after every 100' or after 180 degrees of bends in a conduit run
  - 2. Used to hold splice hardware.
  - 3. Shall be sized as follows:
    - a) One 4" conduit straight through pull:
      - i) 42" wide, 66" long, and 11" deep; minimum.
      - ii) Add 7" to the width for each additional conduit.
      - iii) Information about other trade sizes; reference EIA/TIA 569 standard.
- G. Poke-thru systems:
  - 1. Assembly consisting of disposable plate, barriered raceway, conduit adaptor, housing, base, barrier, and faceplate.

- a) Provide Wiremold RC900-FF3 series multi-service poke-thru with 341-H/B assembly and FP2R faceplates as indicated.
  - 1) Additional approved manufacturers: Hubbell, Walker

## 2.5 ACCESSORIES

### A. Pull wires:

- 1. Pull wires shall be nylon type as manufactured by Arnco or approved equal.
- 2. Provide in all empty conduits, sleeves, raceways, and all cabling pathways for future use.
  - a) Additional approved manufacturers: Greenlee, Condux

### B. Fiber optic innerduct:

- 1. NEMA TC 5, UL listed, corrugated, specifically designed for optical fiber cable pathways.
  - a) Fiber optic innerduct shall be orange in color
  - b) Innerduct shall be 1-inch minimum inside diameter, and a minimum pulling strength of 600 pounds.
  - c) Each innerduct shall include a factory installed pull rope
  - d) Each duct shall be suited for the environment in which it is installed.
  - e) Standard of Quality shall be Carlon DF4X1C-xxxx for installation in Riser rated applications; and, Carlon CF4X1C-xxxx for installation in Plenum environments.
    - 1) Additional approved Manufacturers: Arnco, Endot, Opti-Com, Pyramid

### C. Cable spillways

- 1. Provide Bejed BJ-2049B-002 Spillway on four-inch sleeves; provide Bejed BJ-2049A-001 Cable Spillway on two-inch sleeves.
  - a) Additional approved manufacturers: B-Line, Panduit

### D. Labels

- 1. Standard of quality shall be Brady
  - a) Additional approved manufacturers: Panduit, Hellerman-Tyton

### E. Penetrations through floors and walls

- 1. Sleeves through floors and walls:
  - a) All penetrations through floors or walls to allow Division 27 cable or pathway to pass through will require a UL listed device for the purpose of penetrating the construction.
  - b) Penetrations through walls of spaces utilizing a chemical or pressure system for fire suppression must utilize Wiremold FS series penetration unless an alternate assembly is pre-approved by the Owner.
  - c) Refer the Penetration Sectional View Drawings for UL listed assemblies.
    - 1) Concrete, block, brick, and gypsum drywall construction providing a fire rating of greater than one hour for walls and floors will require a UL rated sleeve assembly installed to manufacturer's requirements

- allowing the penetration(s) to not degrade the designed fire rating of the wall or floor.
- i) Standard of quality shall be as manufactured by Unique Fire Stop Products (USFP). Utilize USFP's Threaded Penetrator system for all fire-rated penetrations.
  - ii) Additional approved manufacturers : Specified Technologies E-Z Path, Wiremold FS Series
- 2) All other penetrations and gypsum drywall constructed walls providing a fire rating of one hour or less will require a UL rated sleeve assembly installed to manufacturer's requirements allowing the penetration(s) to not degrade the designed fire rating of the wall or floor.
- i) Standard of quality shall be as manufactured by Unique Fire Stop Products (USFP). Utilize USFP's Smooth Penetrator system for all fire-rated penetrations.
  - ii) Additional approved manufacturers : Specified Technologies E-Z Path, Wiremold FS Series
- 3) All penetrations found to be improperly sleeved after the installation of cabling will be sleeved and firestopped to restore the proper aesthetics and required fire rating to the obstruction.
- i) Standard of quality shall be as manufactured by Unique Fire Stop Products (USFP). Utilize USFP's split-sleeve system for all fire rated penetrations.
- d) Penetrations into fire rated walls with gypsum board construction.
- 1) All penetrations required in gypsum board walls for installation of horizontal cabling, where conduit is not stubbed into the ceiling cavity for this purpose, will require a sleeved penetration through the drywall membrane or the wall cap.
    - i) Each penetration will require a UL listed sleeve assembly installed by an installer trained on proper installation of the sleeving device.
    - ii) Standard of quality shall be as manufactured by Unique Fire Stop Products (USFP). Utilize USFP's Membrane Penetrator or Cap Penetrator system for all fire rated penetrations.
    - iii) Additional approved manufacturers : Specified Technologies E-Z Path, Wiremold FS Series
  - 2) Standard of quality shall be Unique Fire Stop Products.
    - i) Additional approved manufacturers : Specified Technologies E-Z Path, Wiremold FS Series
- F. Supporting devices – Field Fabricated:
- 1. General
    - a) Shop or field-fabricated supports or manufactured supports assembled from U-channel components.
    - b) Steel brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

- c) All steel components utilized to fabricate supports shall be of U.S. manufacture.
- 2. Coatings:
  - a) Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.
  - b) Where possible, supports shall have a finish similar to the device it is supporting.
    - 1) Where installed below the finished ceiling line, the support shall be painted to match the finish of the device it is supporting.
- 3. Material Types
  - a) Concrete and masonry anchors:
    - 1) Shall be a guaranteed anchoring system with field training available.
      - i) Standard of quality will be as manufactured by Hilti or approved equal.
      - ii) All onsite personnel performing this work will be required to be manufacturer trained on the anchoring system being utilized, and upon request, to show proof of manufacturer's training certification.
  - b) Raceway supports:
    - 1) Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
  - c) Fasteners:
    - 1) Types, materials, and construction features as follows:
      - i) Expansion anchors:
        - (A) Carbon steel wedge or sleeve type
      - ii) Toggle bolts:
        - (A) All steel springhead type
      - iii) Powder-driven threaded studs:
        - (A) Heat-treated steel, designed specifically for the intended service.
  - d) Conduit sealing bushings:
    - 1) 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.
  - e) Cable supports for vertical conduit:
    - 1) Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-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.

- f) Threaded Rod Stock (All-Thread Rod)
  - 1) Available in ¼", 3/8", ½", and 5/8" sizes.
    - i) Utilize ½" for supporting of 12" ladder racks and cable trays.
    - ii) Utilize 5/8" for supporting of 24" ladder racks and cable trays.
  - 2) Rod lengths over 6' will require a "Rod Stiffener" installation for ½" and 5/8" rods.
    - i) A section of U-Channel stock is placed around the rod and stiffener clamp assemblies used to clamp to rod
      - (A) Place clamps a minimum of 6" from the top and bottom of the rod and every 18" in between.
      - (B) Standard of quality shall be B-Line SC228
        - (1) Additional approved manufacturer(s): Unistrut Diversified Products, GS Metals Corp., Haydon Corp., Kin-Line Inc.
- g) U-channel systems:
  - 1) 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.
- 4. Slotted metal angle and U-channel systems:
  - a) Standard of quality shall be Unistrut Diversified Products
    - 1) Additional approved manufacturers: Allied Tube & Conduit, American Electric, B-Line Systems, Inc., Cinch Clamp Co., Inc., GS Metals Corp., Haydon Corp., Kin-Line Inc.

### **PART 3 EXECUTION**

#### **3.1 GENERAL**

- A. Minimum raceway size shall be as necessary to comply with fill ratio of referenced standards, but in no case less than one and one quarter inch (1 1/4 inch).
- B. Provide specified pull wires in all cabling pathways.
- C. Ground and bond all systems in accordance with the NEC and ANSI/TIA/EIA 607.
- D. All installation material and practices shall fully comply with NFPA 70 "National Electrical Code" and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces.
- E. Coordinate work with the building structural systems and electrical installation.
- F. All work shall fully comply with these Specifications and related Drawings and all manufacturers' recommended installation practices.

#### **3.2 PATHWAY INSTALLATION**

- A. Raceways
  - 1. Conduit Usage:
    - a) Rigid Galvanized Steel (GRC):

- 1) All exposed conduit installed above grade outside the building envelope.
    - 2) All conduits installed in moist locations.
  - b) Electric Metallic Tubing (EMT):
    - 1) All conduits within the building envelope.
  - c) Polyvinylchloride (PVC):
    - 1) Underground which may continue from underground through floor slab to Equipment Room/Telecommunications Room.
  - d) Flexible Metal Conduit (FMC):
    - 1) Unless otherwise indicated, FMC can only be provided for secondary pathways from the ceiling space to the telecommunications outlet box.
    - 2) Maximum length shall not exceed 6 meters.
2. Conduit installation:
- a) Provide all conduit terminations with locknuts and bushings. Provide conduits 1 ½ inches and larger with insulating bushings and locknuts inside and outside the enclosure.
    - 1) At least one bushing per conduit shall be grounding type
      - i) Equipped with a ground lug
      - ii) Provide on each conduit or sleeve where surface extends below ceiling line and install Bonding Conductor to TMGB.
  - b) Support conduits by pipe straps or trapeze hangers. Space supports not more than 8 feet on center. Secure supports by means of toggle bolts, inserts or expansion bolts.
  - c) Space wall brackets supporting conduits not more than 4 feet 6 inches on center. Secure supports by means of toggle bolts, inserts or expansion bolts.
  - d) Support conduits directly from structural systems not from ceiling suspensions systems.
    - 1) Provide additional support at junction or pull boxes.
  - e) Wherever possible, conceal raceways under floors, in walls, above ceilings or in furred spaces in finishes areas.
  - f) Support single conduits 1 ½ inches and larger by means of rod and cast ring hangers. Support multiple runs in similar manner or use common trapeze hanger.
    - 1) Trapeze hanger:
      - i) Unistrut P2000 or P4000, or equal by Allied Support systems or Superstrut, as required for span and loading.
      - ii) Provide end caps on hangers.
      - iii) Fasten conduits by means of heavy galvanized straps.
  - g) Provide two hole sheet metal pipe straps for all surface mounted conduit supports on walls up to a height of 8 feet above the finished floor. Pinch type hangers similar to minerallac type may only be used at heights greater than 8 feet.
  - h) Protect conduits during construction with temporary plugs or caps. Securely cap all conduit until wire or cable is installed.

- i) Minimum conduit size is 1 inch.
- j) Do not install conduit in concrete slab.
- k) Provide expansion fittings where raceway crosses the building expansion joints. (O.X. Type AX, EX, EXDS, TX, EXE, or approved equal).
- l) Route and maintain conduits as shown on the Drawings.
  - 1) If no specific routing information appears on the Drawings, the routing shown shall be considered diagrammatic.
    - i) In such a case, the Contractor shall coordinate his Work with the different trades so that interferences between conduit, cable tray, piping, equipment, architectural, and structural work shall be avoided.
      - (A) Should an interference arise, the Contractor shall inform the Consultant before proceeding with the Work.
      - (B) Should the Contractor fail to contact the Consultant and interferences develop, the Owner's Representative will decide which equipment, piping, etc. must be replaced, regardless of which was installed first. The relocation shall be performed at no expense to the Owner.
- m) There shall not be more than the equivalent of 180 degrees of bends in any single run of conduit between adequately sized pull.
- n) Conduit bends
  - 1) Bends shall be made so that the conduit will not be flattened or kinked and the internal diameter of the conduit will not be reduced.
  - 2) The radius of the curve of the inner edge of any bend shall not be less than as indicated by the National Electrical Code and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces.
  - 3) In no case shall any conduit be bent or any fabricated elbow be applied to less than the allowable bending radius as specified by the cable manufacturer of the installed conductor.
  - 4) When necessary to make field bends, use tools designed for conduit bending.
    - i) Heating of metallic conduit to facilitate bending is not permitted.
- o) A conduit run shall not be longer than 100' between pull boxes for conduit runs inside a building.
- p) The Contractor shall not cut, burn, or drill any structural member to mount electrical equipment or to facilitate tray or conduit installations without having previously received approval, in writing, from the Architect/Engineer/Consultant.
- q) Mount all conduits a minimum of 7 inches above any accessible type ceiling.
- r) Maintain conduit runs at least 6 inches from insulated pipes, steam lines or any other hot pipes they pass. Where the lines are not insulated, the clearances shall be increased until the temperature of the conduit, with no

live conductors enclosed, does not rise above the ambient temperature of the installation area.

- s) Conceal all raceways except where otherwise indicated.
  - 1) Provide flashing and counter-flashing or pitch pockets for waterproofing of all raceways, outlets, fittings, etc. that penetrate the roof.
  - 2) Route all raceways parallel or perpendicular to the building lines with symmetrical bends.
  - 3) Provide sleeves in forms for new concrete walls, floor slabs, and partitions for passage of raceways.
    - i) Seal in an approved manner all raceway openings and sleeves through fire rated walls, floors, and ceilings after raceway installation.
- t) Waterproof all sleeved raceways where required.

#### B. Surface Raceway

##### 1. Surface raceway installation

- a) Provide surface raceways as indicated.
- b) Coordinate installation with casework before installation. Field verify lengths to be installed before ordering equipment.
- c) Install plumb and level.
- d) Anchor all raceways to walls with the anchors designed for that particular wall construction. Secure raceway at a minimum of every 2 feet and not less than 6 inches from raceway ends.
- e) Install raceway per the manufacturer's written recommendation, including necessary entrance, end and bend fittings.
- f) Provide all of the manufacturer's recommended fittings and accessories.
- g) Where surface raceway is provided for a secondary pathway from the outlet to the ceiling space, extend surface raceway into the ceiling space not less than 4 inches.

#### C. Telecommunications/power poles

- 1. Mount straight and anchor to building structure above the ceiling line.
- 2. Provide mounting hardware, entrance end fitting, and ceiling trim plate.

#### D. Cable Tray

##### 1. Planning

- a) Contractor shall plan entire cable tray system layout and all components required to provide a complete system, verifying dimensions and right-of-way clearances as needed.
- b) Design
  - 1) Wall mounted
    - i) Where 12" capacity is indicated on the drawings a single tiered 12" rung size tray will be utilized.
    - ii) Where 24" capacity is indicated on the drawings a two tiered 12" rung size tray will be utilized.

- 2) Suspended
  - i) Where 12" capacity is indicated on the drawings a double sided 6" rung size tray will be utilized.
  - ii) Where 24" capacity is indicated on the drawings a double sided 12" rung size tray will be utilized.
2. Coordination and positioning
  - a) Coordinate positioning with other trades to assure maximum accessibility.
    - 1) Tray shall be mounted securely along the wall at a minimum of 6" (lower tier) above the ceiling line.
      - i) Where two 12" trays connect to a two tier unit, the upper tray may continue at 12" (upper tier) above the accessible ceiling.
      - ii) Where tray cannot be wall mounted, (transversing hallways, etc.) mount span securely to wall at each end and provide ½" threaded rod supports, anchored into the concrete deck above, every 4' at minimum.
    - 2) Minimum access should be 12 inches clear above the tray (each tier) and 12 inches clear beside the tray to facilitate moves, adds and changes for telecommunications cabling.
3. Installation
  - a) Cable tray shall be routed as shown schematically by Contract Documents, run level and true to building lines.
  - b) Changes in direction, changes in elevation, tees, crosses, and bends shall be made with manufactured fittings and accessories.
  - c) Where conduits terminate above a cable tray, the conduit shall be provided with an insulating bushing.
  - d) Mounting heights shall be sufficient to clear light fixtures, piping, and equipment and permit ready access through lay-in ceiling grids. Do not install less than 6 inches above ceiling.
  - e) Cable tray shall be grounded by a separate stranded #6 AWG copper ground conductor attached to the building grounding electrode system and connected to nearest section of the cable tray with UL approved aluminum/copper termination.
    - 1) See "Grounding and Bonding" specification for further details.
  - f) Cable tray shall be installed in accessible area. Provide raceway system of equivalent cross section area of cable tray where ceiling system is not accessible.
  - g) Cable tray and all fittings and accessories shall effect a complete structural system in the form of a rigid mechanical tray of compatible material and design, functional to support all cabling.
  - h) Transition cable tray system around physical obstructions using manufacturer's recommended turns, sweeps, transition products, and materials to create a complete continuous cabling pathway free of obstructions and maintaining specified clearances.

- i) Where physical discontinuity is necessary, mechanically support cabling over the discontinuity as specified. Bond the ends of the cable tray together electrically over any discontinuity.
    - 1) Fire-wall penetrations shall be made with 4" sleeves (4 per 12" of tray width minimum).
      - i) Utilize requirements of the NFPA NEC to determine correct construction and sizing of wall penetration if tray is to penetrate fire rated wall.
    - 2) Ground and bond the system in accordance with the NEC and ANSI/TIA/EIA 607.
    - 3) Do not use copper fittings or hardware to connect any bonding conductor to aluminum cable tray.
  - j) Provide support for cable trays at a minimum of 4' 6" on center and at all splices, tees, elbows, bends, intersections, and transitions.
    - 1) Support with threaded rod and U-channel supports systems
      - i) 12" width – 1/2" ATR; 24" width – 5/8" ATR
    - 2) Rod lengths over 6' will require a "Rod Stiffener" installation.
      - i) A section of U-Channel stock is placed around the rod and stiffener clamp assemblies used to clamp to rod
        - (A) Place clamps a minimum of 6" from the top and bottom of the rod and every 18" in between.
  - k) Install system free of all sharp edges, burrs, or projections.
  - l) Provide rung caps on rung ends as specified.
  - m) Provide waterfall fittings in every location that cable is designed to exit the tray downward at the end of a run or between the rungs.
  - n) Route parallel and perpendicular to building surfaces.
  - o) Mount cable tray in such a fashion as to be re-usable.
    - 1) Install as straight and flat as practical and perpendicular to building lines.
      - i) Utilize manufactured 45 degree transitions up and down to change elevations.
      - ii) Utilize manufactured 45 or wide sweep 90 degree fittings to change route.
        - (A) Mount cable tray at approximately 6-12" above accessible ceiling.
        - (B) Locate in a position to allow at least 12" clearance on each side of the cable tray for access.
  - 4. Install as a complete system in accordance with manufacturer's installation instructions indicated on the Drawings and to ensure electrical continuity of the system and adequate support for the cabling. Provide all manufacturer's recommended fittings and accessories.
  - 5. Supports shall be attached to building structure.
- E. Messenger Strand
- 1. Anchors shall be securely mounted to building structure at each end.

2. Tensioners shall be installed to connect strand.
  3. Additional supports shall be installed with threaded rod from the deck above to support the strand approximately 6-8" above suspended ceiling in all locations.
    - a) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
    - b) Properly sized.
      - 1) Multiples of strands (100 horizontal cables each) appropriate to handle the required cable quantities plus 25% spare capacity.
      - 2) Separate strand for Backbone cables.
- F. Open top discreet cable supports (J-Hooks)
1. Primary pathways (corridors, vertical chases, etc.) plenum rated, adjustable cable support that complies with UL cUL, NEC, and ANSI/TIA/EIA requirements for structured cabling systems and accommodates up to 425 horizontal UTP cables or multiples of CAT32 (80 cables each) appropriate to handle the required cable quantities plus 25% spare capacity.
    - a) Install j-hook pathway, supporting at least every 5', as straight as possible perpendicular to building structure at approximately 12" above accessible ceiling.
    - b) Attachment of J-Hooks must be to building structure directly or utilize a minimum of 1/4" all-thread rod anchored into deck above.
  2. Secondary pathways (those extending from the primary pathways to the space above the telecommunications outlets) J-hooks with galvanized finish to provide smooth surface and corrosion resistance that complies with UL, cUL, NEC, and ANSI/TIA/EIA requirements for structured cabling systems and accommodates up to 16 horizontal UTP cables.
    - a) Install j-hook pathway, supporting at least every 5', as straight as possible perpendicular to building structure at approximately 12" above accessible ceiling.
    - b) Attachment of J-Hooks must be to building structure directly or utilize a minimum of 1/4" all-thread rod anchored into deck above.
    - c) Exception: Cable routes of less than ten 4 pair UTP (or equivalent weight) may be supported with ceiling grid support wiring when utilizing a support manufactured for that purpose.
      - 1) Must be supported every 5'
      - 2) Cannot interfere with the removal of the ceiling tile
      - 3) Must be installed approximately 12" above ceiling

### 3.3 BOXES

#### A. Outlet boxes:

1. Provide outlet boxes flush with the surface unless otherwise noted and properly centered in ceiling tiles, wall finishes, or casework elements. Heights as indicated or to match existing outlet boxes.
    - a) Install all telecommunication video outlet with control for locations indicated to be wall hung TV's or monitors 8 feet above finished floor or 12 inches below finished ceiling, whichever is lower.
  2. Provide outlet boxes of a type appropriate for the use and location. Gang adjacent devices in multiple gang boxes under a common finish plate.
  3. Boxes shall be securely and rigidly attached and supported plumb, level, and true to building lines by any of the following methods:
    - a) Double bar installation for metal stud walls. Bar hanger punch, mounting clips, and retainer clips shall be used in strict accordance with manufacturer's instructions. Factory pre-punched stud holes shall not be used to support the bar hangers.
    - b) Steel stud installed behind box for support without caddy-type mounting clips for metal stud wall construction.
    - c) Caddy screw gun bracket installed behind box for support. Installation shall be per manufacturer's instructions.
  4. Finish plates shall not span different types of wall finishes either vertically or horizontally. Plates shall cover mortar joints and cut openings completely.
  5. Outlet, junction, and pull boxes and their covers shall have corrosion protection suitable for the atmosphere in which they are installed. Provide gaskets for all boxes installed outside or in other wet or damp locations (tunnels, crawlspaces, pits, etc.).
  6. Outlet boxes shall be protected from plaster. Debris shall be thoroughly cleaned from the box before installation of conductors.
  7. Floor boxes shall be installed flush and true with the floor.
  8. Finish plates:
    - a) Install a blank coverplate for each new or existing unused outlet box.
- B. Junction and pull boxes
1. Provide junction and pull boxes as indicated in the Contract Documents and as required.
  2. Provide junction and pull boxes in accessible spaces or behind access panels. Boxes located above snap-in or lay-in removable ceilings will be considered accessible.
  3. Provide junction and pull boxes where necessary to facilitate the installation of raceways and pulling of wire or cable.
  4. Provide junction and pull boxes sized in accordance with NEC and installed such that conduit entry will permit the longest radius for conductors contained therein.
  5. Provide junction and pull boxes such that conduits enter and exit across from each other on opposite sides of the junction box. Do not provide junction and pull boxes in place of conduit bends.

6. Support all such boxes in accordance with the National Electrical Code.

C. Mounting heights

1. Exceptions:

- a) At junction of different materials in wall finishes.
- b) Where outlet would occur in moldings, break in wall surface or unsuitable location in the tile, wood, or similar finish.
- c) Where outlets would conflict with locations of wall-mounted equipment such as radiators, convectors, unit heaters, etc.
- d) As noted otherwise.
- e) Where electrical outlet on that wall is of different height.

3.4 PENETRATIONS THROUGH FLOORS AND WALLS

A. General:

- 1. Provide, locate and set sleeves where conduit passes through floors, walls, and other concrete or masonry structural materials except where tunnels, chases or shafts are provided in the constructions.
  - a) Sleeves through poured-in-place concrete floors shall be set before the pour and shall be of a design that will seal against passage of water between sleeves and concrete floor.
- 2. Provide bushings on all conduit sleeves.
- 3. Extend all wall sleeves a minimum of 2 inches or as required to allow the installation of conduit bushings.
- 4. Extend floor sleeves 4-6 inches above finished floors unless otherwise specified.
- 5. The void between the sleeve wall and conduit shall be neatly filled with an approved fire stop material.

B. Quantity and sizing:

- 1. Penetrations through floors, access through walls of Equipment Rooms and/or Telecommunications Rooms, and obstructions along a backbone or primary horizontal cabling route.
  - a) Provide the required quantity of 4 inch sleeve assemblies as specified with a minimum of one 4 inch sleeve. Properly firestop after installation of the telecommunications cabling.
  - b) Install sizes and quantities as specifically noted on the prints, or the quantity required so as to accommodate all planned cables, not exceeding a 40 percent maximum fill ratio in each sleeve, plus one spare 4 inch sleeve.
- 2. Penetrations through walls or along secondary horizontal cabling routes.
  - a) Provide a 2 inch or 4 inch sleeve assembly as specified with a minimum of one 2 inch sleeve. Properly fire stop after installation of the telecommunications cabling.
  - b) Install sizes and quantities as specifically noted on the prints, or the quantity required so as to accommodate all planned cables, not exceeding a 40 percent maximum fill ratio in each sleeve, plus one spare 4 inch sleeve.

C. Construction:

1. All penetrations through floors or walls to allow Division 27 cable or pathway to pass through will require a UL listed device for the purpose of penetrating the construction.
  - a) Concrete, block, brick, and gypsum drywall construction providing a fire rating of greater than one hour for walls and floors will require a UL rated sleeve assembly installed to manufacturer's requirements allowing the penetration(s) to not degrade the designed fire rating of the wall or floor.
    - 1) Each penetration will require a UL listed sleeve assembly installed by an installer trained on proper installation of the sleeving device.
    - 2) Each penetration shall have the accompanying certification paperwork completely filled out and attached to the building structure adjacent to the penetration.
2. All other penetrations and gypsum drywall constructed walls providing a fire rating of one hour or less will require a UL rated sleeve assembly installed to manufacturer's requirements allowing the penetration(s) to not degrade the designed fire rating of the wall or floor.
  - a) Each penetration will require a UL listed sleeve assembly installed by an installer trained on proper installation of the sleeving device.
  - b) Each penetration shall have the accompanying certification paperwork completely filled out and attached to the building structure adjacent to the penetration. A copy of this paperwork will be required in the O & M Manual.
3. All penetrations found to be improperly sleeved after the installation of cabling will be sleeved and firestopped to restore the proper aesthetics and required fire rating to the obstruction.
  - a) Each penetration will require a UL listed sleeve assembly installed by an installer trained on proper installation of the sleeving device.
  - b) Each penetration shall have the accompanying certification paperwork completely filled out and attached to the building structure adjacent to the penetration. A copy of this paperwork will be required in the O & M Manual.
4. All penetrations required in gypsum board walls for installation of horizontal cabling, where conduit is not stubbed into the ceiling cavity for this purpose, will require a sleeved penetration through the drywall membrane or the wall cap.
5. Each penetration will require a UL listed sleeve assembly installed by an installer trained on proper installation of the sleeving device.

3.5 SUPPORTS

A. General:

1. Coatings

- a) Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using

approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

b) Concrete and masonry anchors

1) Shall be a guaranteed anchoring system with field training available.

- i) All onsite personnel will be required to be manufacturer trained on the anchoring system being utilized, and upon request, to show proof of manufacturer's training certification.

B. Manufactured supporting devices:

1. Raceway supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.
2. Fasteners: Types, materials, and construction features as follows:
  - a) Expansion anchors: Carbon steel wedge or sleeve type
  - b) Toggle bolts: All steel springhead type
  - c) Powder-driven threaded studs: Heat-treated steel, designed specifically for the intended service
3. 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.
4. Cable supports for vertical conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-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.
5. 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.

C. 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. Raceway supports: Comply with the NEC and the following requirements.
  - a) Conform to the manufacturer's recommendations for selection and installation of supports.
  - b) 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 lbs. provide additional strength until there is a minimum of 200 lbs. safety allowance in the strength of each support.

- c) 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.
  - d) Support parallel runs of horizontal raceways together on trapeze-type hangers.
  - e) Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers for 1 ½ inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use ¼ inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
  - f) Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
  - g) In vertical 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.
4. Miscellaneous supports:
- a) Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, pull boxes, junction boxes, and other devices.
  - b) Support sheet 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 approved type of fastener not more than 24 inches from the box.
5. Conduit seals:
- a) Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
6. Fastening:
- a) Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to; conduits, raceways, cables, cable traps, busways, cabinets, panelboards, 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, machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead

- of expansion bolts and machine or wood screws. 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 ½ inch in reinforced concrete beams or to depth of more than ¾ inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
  - 3) Ensure that the load applied to any fasteners does not exceed 25 percent of the proof test load. Use vibration-and shock-resistant fasteners for attachments to concrete slabs.
7. Raceway supports: Hanger spacing shall be as required for proper and adequate support of raceway, but in no case shall be less than one hanger per 5 feet of raceway length.

**END OF SECTION**

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## **FIRESTOPPING FOR COMMUNICATIONS SYSTEMS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

- 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.**

#### **1.2 SUMMARY**

- A. Section Includes:

- 1. This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.**

- a) Refer to related Section 27 05 28 “Pathways for Communications Systems” for Sleeving requirements.
- b) This Section includes firestopping for the following:
  - 1) Penetrations through fire-resistance/-rated floor and roof construction including both empty openings and openings containing cables, pipes, ducts, conduits, and other penetrating items.
  - 2) Penetrations through fire-resistance/-rated walls and partitions including both empty openings and openings containing cables, pipes, ducts, conduits, and other penetrating items.
  - 3) Penetrations through smoke barriers and construction enclosing compartmentalized areas involving both empty openings and openings containing penetrating items.
  - 4) Sealant joints in fire-resistance/-rated construction.
- c) Label each firestopped sleeve with the label furnished with the sleeve assembly; each certification label shall be copied and added to the O & M Manual.

- 2. System includes but is not limited to:**

- a) Firestopping Compounds

- B. Related Sections

- 1. All Division 27 Sections**

- C. Related Drawings

- 1. Technology (T-Series) Drawings**

#### **1.3 GENERAL INFORMATION**

A. Definitions:

**1. Firestopping**

- a) A material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flames, smoke, and/or hot gasses through penetrations in fire-rated wall and floor assemblies.

B. All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.

1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

A. General:

- 1. Provide firestopping systems that are produced and installed to resist the spread of fire, according to requirements indicated, and the passage of smoke and other gasses.**
- 2. Firestopping may be factory installed in a re-usable sleeve assembly or may be a removable/ re-usable material(s) inserted into a sleeve assembly to provide adequate protection.**
- 3. Refer to related Division 27 Section "Pathways for Communications Systems" for Sleeving requirements.**

B. Fire stopping requirements/locations are not indicated on drawings. It shall be the responsibility of this contractor to review all architectural and other drawings to determine fire/smoke rated walls and floors and rating requirements of same. This contractor shall provide all required fire stopping work associated with all Division 27 penetrations. Provide fire stop pillows, putty and/or sealant, as applicable, with minimum UL classification for 1 hour fire and cold side temperature ratings.

- 1. At a minimum, provide firestopping to equal or exceed the rating of the wall or floor.**
- 2. Provide Fire Stop Putty equal to Nelson FSP #AA400 series, or by 3M Fire Protection Products; Fire Protection Services, Inc.; UL Classified for 3 hour fire and cold side temperature ratings, reusable when penetrating items are removed or added and requiring no special tools, mixing, curing or drying time.**

C. System Performance requirements:

- 1. Provide re-usable firestopping system(s) in all backbone pathway and major horizontal routes.**
- 2. F-rated through-penetration firestop systems:**
  - a) Provide through-penetration firestop systems with F rating indicated, as determined per ASTM E 814, but not less than that equaling or exceeding the fire-resistance rating of the constructions penetrated.

**3. T-rated through-penetration firestop systems:**

- a) Provide through-penetration firestop systems with T ratings, in addition to F ratings, as determined per ASTM E 814 where indicated and where systems protect penetrating items exposed to contact with adjacent materials in occupied floor areas. T-rated assemblies are required where the following conditions exist:
  - 1) Firestop systems protect penetrations located outside of wall cavities.
  - 2) Firestop systems protect penetrations located outside fire-resistive shaft enclosures.
  - 3) Firestop systems protect penetrations located in construction containing doors required to have a temperature-rise rating.
  - 4) Firestop systems protect penetrating items larger than a 4-inch (100 mm) diameter nominal pipe or 16 sq. in. (100 sq. cm) in overall cross-sectional area.
- 4. Fire-resistive joint sealants:**
  - a) Provide joint sealants with fire-resistance ratings indicated, as determined per ASTM E 119, but not less than that equaling or exceeding the fire-resistance rating of the construction in which the joint occurs.
- 5. For firestopping exposed to view, traffic, moisture, and physical damage, provide products that do not deteriorate when exposed to these conditions.**
  - a) For floor penetrations with annular spaces exceeding 4 inches (100 mm) or more in width and exposed to possible loading and traffic, provide firestop systems capable of supporting the floorloads involved either by installing floor plates or by other means.
  - b) For penetrations involving insulated piping, provide through-penetration firestop systems not requiring removal of insulation.
- 6. For firestopping exposed to view, provide products with flame-spread values of less than 25 and smoke-developed values of less than 450, as determined per ASTM E 84.**

## 1.5 SUBMITTALS

### A. General

- 1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.**
- 2. Samples shall be submitted with or immediately following submission of Product Data submittals.**

### B. Items to be submitted for approval prior to commencement of work:

#### **1. Product Data**

- a) Manufacture datasheets for all items
  - 1) Data sheets shall include
    - i) Manufacturer name
    - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
    - iii) Manufacturer product description
    - iv) Paragraph number of this section where the product is specified.

**2. Shop Drawings**

- a) System block wiring diagram, detailed.

**C. Quality Assurance / Control Submittals**

- 1. RCDD Certification for the staff member responsible for this project.**
- 2. Resume of the last 10 projects of the RCDD responsible for this project**
- 3. BICSI Technician's certificate for each lead Technician(s) on the project**

**D. Closeout Submittal**

- 1. Manufacturer's Material Safety Data Sheets (MSDS) for each item.**
- 2. Product certificates signed by manufacturers of firestopping products certifying that their products comply with specified requirements.**

**PART 2 PRODUCTS**

**2.1 PRODUCT STANDARDS**

**A. General**

- 1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.**
- 2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.**

**2.2 FIRESTOPPING, GENERAL**

**A. Compatibility:**

- 1. Provide firestopping components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by firestopping manufacturer based on testing and field experience.**

**B. Accessories:**

**1. Provide components for each firestopping system required to install fill materials and to comply with “System Performance Requirements” Article in Part 1. Use only components specified by the firestopping manufacturer and approved by the qualified testing and inspecting agency for the designated fire-resistance-rated systems. Firestopping materials shall be asbestos-free and shall not contain flammable solvents. Accessories include but are not limited to the following:**

- a) Permanent forming/damming/backing materials including the following:
  - 1) Semi-refractory fiber (mineral wool) insulation
  - 2) Ceramic fiber
  - 3) Sealants used in combination with other forming/damming materials to prevent leakage of fill materials in liquid state
  - 4) Fire-rated formboard
  - 5) Joint fillers for joint sealants
- b) Temporary forming materials
- c) Substrate primers
- d) Collars
- e) Steel sleeves

C. Applications:

**1. Provide firestopping systems composed of materials specified in this Section that comply with system performance and other requirements.**

## 2.3 FILL MATERIALS FOR THROUGH-PENETRATION FIRESTOP SYSTEMS

A. Subject to compliance with requirements, provide one or more of the following types:

B. Ceramic-fiber and mastic coating:

**1. Ceramic fibers in bulk form formulated for use with mastic coating and ceramic fiber manufacturer’s mastic coating.**

- a) Standard of quality shall be 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): Thermal Ceramics, FireMaster Bulk, FireMaster Mastic

C. Ceramic-fiber sealant:

**1. Single-component formulation of ceramic fibers and inorganic binders.**

- a) Standard of quality shall be 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): Metacaulk 525, The RectorSeal Corporation

D. Endothermic, latex compound sealant:

**1. Single-component, endothermic, latex formulation.**

- a) Standard of quality shall be 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): Fyre-Shield, Tremco Inc., Flame-Safe FS500/600 Series, International Protective Coatings Corp., Flame-Safe FS900/FST900 Series, International Protective Coating Corp., Cafco TYPS Type 1, Isolatek International, STI LC150, Specified Technologies, Inc.

E. Intumescent, latex sealant:

**1. Single-component, intumescent latex formulation.**

- a) Standard of quality shall be Fire Barrier CP 25WB Caulk, 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): Metacaulk 950, The RectorSeal Corporation, Cafco TPS Type 1, Isolatek International, STI SSS100, Specified Technologies, Inc., Hilti

F. Intumescent putty:

**1. Nonhardening, dielectric, water-resistant putty containing no solvents, inorganic fibers, or silicone compounds.**

- a) Standard of quality shall be Fire Barrier Moldable Putty, 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): Intumescent Putty, General Electric Co., Flame-Safe FSP1000 Putty, International Protective Coatings Corp., Cafco TPS Types P and EP, Isolatek International, Hilti

G. Intumescent wrap strips:

**1. Single-component, elastomeric sheet with aluminum foil on one side.**

- a) Standard of quality shall be Fire Barrier FS-195 Wrap/Strip, 3M Fire Protection Products
  - 1) Additional approved manufacturer(s): CS2420 intumescent wrap, Hilti Construction Chemicals, Inc., STI SSW Red, Specified Technologies, Inc.

H. Pillows/bags:

**1. Reusable, heat-expanding pillows/bags composed of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents and fire-retardant additives.**

- a) Standard of quality shall be Firestop Pillows, Bio Fireshield, Inc.
  - 1) Additional approved manufacturer(s): KBS Sealbags, International Protective Coatings Corp., SSB Pillows, Specified Technologies, Inc., 3M Fire Protection Products

I. Intumescent collars:

- a) Standard of quality shall be Cafco TPS Type D, Isolated International

- b) Additional approved manufacturer(s): STI SSC Collars, Specified Technologies, Inc., 3M Fire Protection Products

## 2.4 FIRE-RESISTIVE ELASTOMERIC JOINT SEALANTS

### A. Elastomeric sealant standard:

1. **Provide manufacturer's standard chemically curing, elastomeric sealants for base polymer indicated that complies with ASTM C 920 requirements, including those referenced for type, grade, class, and uses; and requirements specified in this Section applicable to fire-resistive joint sealants.**

### B. Single-component, neutral-curing silicone sealant:

1. **Type S, Grade NS, Class 25, exposure-related Use NT, and joint-substrate related Uses M, G, A, and (as applicable to joint substrates indicated) O.**

#### a) Additional movement capability:

- 1) Provide sealant with the capability to withstand the following percentage changes in joint width existing at time of installation, when tested for adhesion and cohesion under maximum cyclic movement per ASTM C 719, and remain in compliance with other requirements of ASTM C 920 for uses indicated:
  - i) 50 percent movement in both extension and compression for a total of 100 percent movement.
  - ii) 100 percent movement in extension and 50 percent movement in compression for a total of 150 percent movement.

### C. Single-component, nonsag, urethane sealant:

1. **Type S, Grade NS, Class 25, and Uses NT, M, A, and (as applicable to joint substrates indicated) O.**

### D. Products: Subject to compliance with requirements, provide one of the following:

#### 1. Single-component, neutral-curing, silicone sealant:

- a) Dow Corning 790, Dow Corning Corp.
- b) Dow Corning 795, Dow Corning Corp.
- c) Silpruf, General Electric Co.
- d) Ultraglaze, General Electric Co.
- e) Omniseal, Sonneborn Building Products Div. Chem Rex, Inc.
- f) Hilti
- g) FS-One

#### 2. Single-component, nonsag, urethane sealant:

- a) Isoflex 880 GB, Harry S. Peterson Co., Inc.
- b) Isoflex 881, Harry S. Peterson Co., Inc.

- c) Vulkem 921, Mameco International Inc.
- d) Sikaflex-15LM, Sika Corp.
- e) NP-1, Sonneborn building Products Civ., Chem Rex, Inc.

## 2.5 FIRE STOPPING FOR ALL OTHER WALL AND FLOOR OPENINGS

- A. Provide Fire Stop Sealant shall be equal to Nelson #AA491 series, or by 3M Fire Protection Products; Fire Protection Services, Inc.; UL Classified for 3 hour fire and cold side temperature ratings, non-sagging, permanently flexible, non-toxic, non-shrinking, water/air/smoke-tight and easily re-penetrated. The following shall be considered equal.
  - 1. **For Floor Openings:** **Instant Firestop; 305-SL.**
  - 2. **For Wall Openings:** **Instant Firestop; 344-GG.**
  - 3. **Mineral Felt:** **Instant Firestop; Type MW.**
  - 4. **For Insulated Pipes:** **Instant Firestop; Type PI.**
  - 5. **For Fill Areas:** **Instant Firestop; C-1000.**
- B. Apply sealant primer to substrates as recommended by manufacturer (if any). Protect adjacent areas from spillage and migration of primers, using masking tape. Remove tape immediately after tooling without disturbing joint seal.
- C. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

## PART 3 EXECUTION

### 3.1 PROJECT CONDITIONS

- A. Environmental conditions:
  - 1. **Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.**
- B. Ventilation:
  - 1. **Ventilate firestopping compounds per manufacturers' instructions by natural means or, when this is inadequate, forced air circulation.**

### 3.2 SEQUENCING AND SCHEDULING

- A. **Do not cover up those firestopping installations that will become concealed behind other construction until the Architect/Engineer/Consultant has examined each installation**

### 3.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver firestopping products to the Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, lot number, shelf life, if applicable, qualified testing and inspecting agency's classification marking applicable to Project, curing time, and mixing instructions for multi-component materials.
  - 1. Coordinate the delivery date of firestopping materials with the scheduled date of installation to minimize amount of storage time required at the Project site.**
  - 2. Store with a copy of the manufacturers MSDS sheet.**
    - a) Submit a copy of each sheet to the site manager.
- B. Store and handle firestopping materials to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.
- C. **Damaged or expired materials shall be removed from the site and shall not be used in the Work.**

### 3.4 FIRE-TEST-RESPONSE CHARACTERISTICS: PROVIDE FIRESTOPPING THAT COMPLIES WITH THE FOLLOWING REQUIREMENTS AND THOSE SPECIFIED IN THE "SYSTEM PERFORMANCE REQUIREMENTS" ARTICLE IN THIS SECTION.

- A. Firestopping tests are to be performed by a qualified testing and inspecting agency. A qualified testing and inspecting agency is an agency performing testing and follow-up inspection services for firestop systems that is acceptable to authorities having jurisdiction.
- B. Through-penetration firestop systems are identical to those tested per ASTM E 814 under conditions where positive furnace pressure differential of at least 0.01 inch of water (2.5 Pa) is maintained at a distance of 0.78 inch (20 mm) below the fill materials surrounding the penetrating items in the test assembly. Provide rated systems complying with the following requirements:
  - 1. Through-penetration firestop system products shall bear classification marking of qualified testing and inspecting agency.**
  - 2. Through-penetration firestop systems correspond to those indicated by reference to through-penetration firestop system designations listed by UL in their "Fire Resistance Directory," by Warnock Hersey, or by another qualified testing and inspecting agency.**
- C. Fire-resistive joint sealant systems are identical to those tested for fire-response characteristics per ASTM E 119 under conditions where the positive furnace pressure differential is at least 0.01 inch of water (2.5 Pa) as measured 0.78 inch (20 mm) from the face exposed to furnace fire. Provide systems complying with the following requirements:
  - 1. Fire-resistance rating of joint sealants**

- a) As indicated by reference to design designations listed by UL in their “Fire Resistance Directory” or by another qualified testing and inspecting agency.

**2. Joint sealants, including backing materials, bear classification marking of qualified testing and inspection agency.**

- D. Where no UL test firestop application exists, manufacturer’s engineering judgment derived from similar UL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation.
- E. Firestopping systems and their locations in the Project are not specifically indicated in the Drawings.
- F. It is the sole responsibility of the Firestopping Contractor to install tested and approved systems that comply with all applicable codes, standards and/or agencies having jurisdiction.

**3.5 INSTALLER QUALIFICATIONS:**

- A. Engage an installer with not less than two years experience in the installation of firestopping similar in material, design, and extent to that indicated for this Project.

**3.6 SINGLE-SOURCE RESPONSIBILITY:**

- A. Obtain through-penetration firestop systems for each kind of penetration and construction condition indicated from a single manufacturer.

**3.7 PROVIDE FIRESTOPPING PRODUCTS CONTAINING NO DETECTABLE ASBESTOS AS DETERMINED BY THE METHOD SPECIFIED IN 40 CFR PART 763, SUBPART F, APPENDIX A, SECTION 1, “POLARIZED LIGHT MICROSCOPY.”**

**3.8 COORDINATING WORK:**

- A. Coordinate construction of openings and penetrating items to ensure that designated through-penetration firestop systems are installed per specified requirements.

**3.9 EXAMINATION**

- A. Examine substrates and conditions with installer present for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of firestopping. Do not proceed with installation until unsatisfactory conditions have been corrected.

**3.10 PREPARATION**

- A. Surface cleaning:

**1. Clean out openings and joints immediately before installation of firestopping to comply with firestopping manufacturer’s recommendations and the following requirements:**

- a) Remove all foreign materials from surfaces of opening and joint substrates and from penetrating items that could interfere with adhesion of firestopping.
  - b) Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
  - c) Remove laitance and form release agents from concrete.
- B. Masking tape:
- 1. Use masking tape to prevent firestopping from contact with the following:**
    - a) Adjoining surfaces that will remain exposed upon completion of Work.
    - b) Surfaces that would otherwise be permanently stained or damaged by such contact or cleaning methods used to remove smears from firestopping materials.
  - 2. Remove tape as soon as it is possible to do so without disturbing firestopping seal with substrates.**

### 3.11 GENERAL FIRE STOPPING MATERIAL APPLICATION

- A. Clean all affected surfaces, joints, etc. immediately before applying fire stopping to comply with recommendations of manufacturer.
- B. Comply with fire stop material manufacturers' printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
- C. Install fire stop materials, including forming, packing, and other accessory materials, to fill openings around services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.
- D. Caulk between sleeves and pipes with rockwool and caulk around sleeves with sealing compound. Material must meet all applicable fire ratings required.
- E. Patch shall be equal to rockwool, firestop, caulk or approved "rated" patch.
- F. Where a smoke and/or fire-resistance classification is indicated on architectural drawings or otherwise, provide the following as applicable.
- G. Fire stop pillows, putty and/or sealant with minimum UL classification for 3 hour fire and cold side temperature ratings for all penetrations.
- H. Access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating required; Provide UL Label on each fire-rated access door.
- I. Wall and Floor Opening Fire Stopping for Open Cable Tray or J-Hook Paths
- J. Provide Fire Stop Pillows equal to Nelson FSP #AA500 PLW or #AA501 PLW or by Fire Protection Services, Inc.; 3M Fire Protection Products as required, UL Classified for 3 hour fire and cold side temperature ratings, quickly removable and reusable, non-toxic and requiring no special tools.

- K. Wall & Floor Opening Fire Stopping for Work Likely to Require Ongoing Moves, Adds and Changes
- L. All Work shall comply with manufacturer's written installation instructions.
  - 1. **Seal all holes to ensure a flame/gas/smoke resistant seal.**
  - 2. **Do not permit UL firestop systems to hamper the performance of fire dampers in ductwork.**

### 3.12 INSTALLING THROUGH-PENETRATION FIRESTOPS

- A. General:
  - 1. **Comply with the "System Performance Requirements" Article in Part 1 and the through-penetration firestop manufacturer's installation instructions and drawings pertaining to products and applications indicated.**
- B. Install forming/damming materials and other accessories of types required to support fill materials during their application and in the position needed to produce the cross-sectional shapes and depths required to achieve fire ratings of designated through-penetration firestop systems. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:
  - 1. **Completely fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.**
  - 2. **Apply materials so they contact and adhere to substrates formed by openings and penetrating items.**

### 3.13 INSTALLING FIRE-RESISTIVE JOINT SEALANTS

- A. General:
  - 1. **Comply with the "System Performance Requirements" Article in Part 1, with ASTM C 1193, and with the sealant manufacturer's installation instructions and drawings pertaining to products and applications indicated.**
- B. Install joint fillers to provide support of sealants during application and at the position required to produce the cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability and develop fire-resistance rating required.
- C. Install sealants by proven techniques that result in sealants directly contacting and fully wetting joint substrates, completely filling recesses provided for each joint configuration, and providing uniform, cross-sectional shapes and depths relative to joint width at optimum sealant movement capability. Install sealants at the same time joint fillers are installed.
- D. Tool nonsag sealants immediately after sealant application and before skinning or curing begins. Form smooth, uniform beads of configuration indicated or as required to produce fire-resistance rating, as well as to eliminate air pockets, and to ensure contact and adhesion of sealants with sides of joint. Remove excess sealant from

surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or that are not approved by the sealant manufacturer.

### 3.14 FIELD QUALITY CONTROL

- A. Do not proceed to enclose firestopping with other construction until examinations are completed.
- B. Where deficiencies are found, repair or replace firestopping at no additional expense to the Owner so that Work complies with requirements.

### 3.15 CLEANING

- A. Remove excess fill materials and sealants adjacent to openings and joints as Work progresses. Use methods and cleaning materials approved by manufacturers of firestopping products and products in which openings and joints occur. Return all surfaces to their original condition.
- B. During and after the curing period, protect firestopping from contact with contaminating substances and from damage resulting from construction operations or other causes so that they are without deterioration or damage or at time of Substantial Completion.
  - 1. **If damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.**

**END OF SECTION 270550**

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## IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Labeling of Communications Systems
  - 2. Labeling of Life Safety and Security Systems
    - a) This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
  - 3. System includes but is not limited to:
    - a) Labels
- B. Related Sections
  - 1. All Division 27 Sections
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### 1.3 REFERENCES

- A. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. Furnish and install labeling for all Communication products, including but not limited to:
  - 1. Patch panels
  - 2. Device plates
  - 3. Cabling
  - 4. Equipment racks
  - 5. Building Distribution Frame <BDF>/Entrance Facility <EF>
  - 6. Equipment room(s) <ERxxxx>
  - 7. Telecommunications room(s) <TRxxx>
  - 8. Structured cabling, including horizontal and backbone cabling
  - 9. Communications cabling cross-connects
  - 10. Communications backboards

B. Labeling system shall be an ANSI/TIA/EIA-606 compliant system - The Administrative Standard for the Telecommunications Infrastructure of Commercial Building Identification System.

1. See Drawings for graphical representation.

## 1.5 SUBMITTALS

### A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.

2. Samples shall be submitted with or immediately following submission of Product Data submittals.

### B. Product Data

1. Manufacture datasheets for all labels

### C. Shop Drawings

1. Labeling system diagram, detailed.

### D. Quality Assurance

1. RCDD Certificate for the Contractor's staff member(s) with ultimate responsibility for ensuring Contractor compliance with work of this section.

2. BISCO Technician Certificate for the technicians performing work of this section

### E. Closeout Submittals

1. A diagram of the labeling scheme used on the Project.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

A. Brady

B. Panduit

C. Hellerman/Tyton

D. Brother

### 2.2 GENERAL

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not listed in Part 2, will be evaluated as a performance specification based on the information provided on the Drawings.

## 2.3 LABELS

### A. Labels

1. Labels shall have a white background and black print.
2. Provide alphanumeric, clearly typewritten labels at all designated points as follows:
  - a) Horizontal Cables
    - 1) 4 pair UTP cables
      - i) Standard of quality shall be Brady PTL-31-642
    - 2) 4 pair STP cables
      - i) Standard of quality shall be Brady PTL-21-642
    - 3) RG-6 Coaxial
      - i) Standard of quality shall be Brady PTL-31-642
  - b) Telecommunications outlet port
    - 1) Standard of quality shall be Panduit PLL-46-Y2-1
  - c) Telecommunications outlet faceplate:
    - 1) Standard of quality shall be Panduit JLEFPS-1
  - d) Patch panel ports
    - 1) Standard of quality shall be Panduit JLCPL-1
  - e) Patch Panels
    - 1) Standard of quality shall be Brady PTL-20-422
  - f) Backbone cables
    - 1) 100 pair Copper cables
      - i) Standard of quality shall be Brady PTL-34-642
    - 2) Fiber Optic Cables
      - i) Standard of quality shall be Brady PTL-21-642
    - 3) Cable Bundles
      - i) Standard of quality shall be Brady PTL-12-109
    - 4) 110 style blocks
      - i) Standard of quality shall be Panduit DSL-110
      - ii) Use with Panduit P110LH
    - 5) Telecommunications Backboards
      - i) Standard of quality shall be Brady PTL-37-422
    - 6) Racks and Cabinets
      - i) Standard of quality shall be Brady PTL-42-422

## **PART 3 EXECUTION**

### **3.1 GENERAL**

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.
- B. Contractor SHALL work with Owners Telecommunications representative to gain approval of labeling plan BEFORE any cable labeling is started.
- C. Jacks in patch panels shall be installed with room numbers in sequential numerical order and in floor order.

### **3.2 INSTALLATION**

#### **A. Labels**

- 1. Apply all labels shall be installed parallel to the dominate visual lines of the product being labeled.
- 2. Labels shall be clearly legible and appropriately sized for the application.
- 3. Provide alphanumeric, clearly typewritten labels at all designated points as follows:

- a) See for graphical representation of labeling scheme.
- b) Horizontal cabling:

- 1) Cabling to ER/TR from outlets and devices

- i) ER/TR # - Outlet Room Number - Patch Panel #/Port #.
    - ii) Example: ER01-211-B22 where Equipment Room is identified as ER01, the cable travels to room 211 and the cable is landed on patch panel B position 22 (of 48) in the ER.
    - iii) Locate label on cable jacket between 3 and 6 inches of each end of the cable.

- 2) Cabling between horizontal outlets/devices

- i) Label local input cables.
    - ii) Locate label on cable jacket between 3 and 6 inches of each end of the cable.
    - iii) Label each cable as to its signal type, purpose, and destination. Add a numeric suffix to uniquely identify multiple cables of duplicate signal type, purpose or destination.

- c) Telecommunications outlet ports and faceplates:

- 1) ER/TR# - Outlet Room Number – Patch panel #/ Jack #.
  - 2) Example: ER01-211 faceplate number and B22 through B25 jack numbers for a 4 port faceplate where Equipment Room is identified as

- ER01, the cable is landed on patch panel B position 22 through 25 (of 48) in the ER and travels to room 211.
- 3) Locate the faceplate label, excluding the jack designation at the top of the faceplate. Locate the individual jack designation numbers immediately above each jack on the faceplate.
  - 4) Label local input terminations as follows: F Connector – Camera, RCA yellow – Local Video, RCA white – L Audio, RCA red– R Audio, BNC – Local Video, Horizontal UTP – Local Control.
- d) Patch panels and patch panel ports:
- 1) Label each patch panel A-Z, top-to-bottom
    - i) Locate label on the front upper left corner of all patch panels
  - 2) Locate on the front of all patch panels, directly above or below (as indicated by the manufacturer) each jack position (1 through 24) in the patch panel; place the room number corresponding to the room number used on the faceplate for each port.
  - 3) Labeling shall be in numerical order and correspond to the telecommunications outlet faceplate scheme.
- e) Backbone cabling:
- 1) Service designation – ER#/TR#.
  - 2) Service designation – CB = Copper Backbone, FB = Fiber Backbone, VB = Video Backbone. Example: CB – ER01/TR02.
  - 3) Locate label on cable jacket within 6 inches of each end of the cable and at key pull points along pathway.
- f) Cross-connect blocks, 110 style
- 1) Locate on the front of all patch panels directly above or below (as indicated by the manufacturer) each position in the block.
  - 2) Labeling shall be in numerical order and correspond to the telecommunications outlet faceplate scheme or opposite end labeling dependant on use.
  - 3) Label the upper left corner of each block designating the service of that particular block. Do not terminate mixed services on the same block.
- g) Cross-connect blocks, 66 style
- 1) Locate on the front of all patch panels directly above or below (as indicated by the manufacturer) each position in the block.

- 2) Labeling shall be in numerical order and correspond to the telecommunications outlet faceplate scheme or opposite end labeling dependant on use.
- 3) Label the upper left corner of each block designating the service of that particular block. Do not terminate mixed services on the same block.
- h) Communications Backboards (TBB)
  - 1) Backboard # with the prefix TBB, followed by the numeric backboard number in the room, followed by the suffix identifying the room in which the backboard is located. Example: TBB-01-ER-xxx.
  - 2) Label each 4'x8' sheet and each partial sheet, in numerical order left-to-right as facing the front of the backboards.
- i) Equipment Racks
  - 1) Device ID. Example: ER01 – 02.
  - 2) Label each cabinet/rack in numerical order left-to-right as facing front of cabinet/rack bays.
- j) Telephone Patch Cables
  - 1) Labeled with the same unique identifier at both ends of the assembly.

### 3.3 TRAINING

- A. Conduct a walk through of the project site and demonstrate the presence and location of all key labeling elements used.
- B. Furnish handouts to all owner personnel attending training that clearly depicts the labeling schema used on the project.

**END OF SECTION 27 05 53**

## VERIFICATION TESTING OF STRUCTURED CABLING

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. The work covered by this Specification Section includes any and all requirements for this type work required for proper Commissioning of work specified in each related Division 27 Specification Section and/or as shown on the Drawings.
  - 2. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing of the work called for in the Contract Documents.
    - a) This Section is a “Common Work Results” Section that includes information that is applicable and “Related” to all Division 27 Sections.
- B. Related Sections
  - 1. All Division 27 Sections
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### 1.3 REFERENCES

- A. All testing procedures and field-test instruments shall comply with applicable requirements of:
  - 1. ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
  - 2. ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements
  - 3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.
  - 4. ANSI/TIA/EIA-455-133A, Measurement of Fiber or Cable Length Using an OTDR.
  - 5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.
  - 6. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant.

7. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
8. ANSI/TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard,
9. TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems.
- B. ANSI/TIA/EIA-568-C.2 – Balanced Twisted Pair Telecommunications Cabling and Components Standard
- C. ANSI/TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard
- D. ANSI/TIA/EIA-568-C.4 – Standard on Coaxial Cabling Components
- E. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

##### A. General

1. Testing shall be carried out in accordance with this document.
2. Testing shall be performed on each cabling link (connector to connector).
3. Testing shall not include any active devices or passive devices within the link other than cable, connectors, and splices.
  - a) Link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
4. Contractor shall maintain and provide to ISU a Microsoft Excel spreadsheet in electronic format of all connections installed with the following fields filled out. **NO DATA PORTS WILL BE ACTIVATED UNTIL THIS SHEET IS PROVIDED FULLY FILLED OUT TO OWNER.**
  - a) Room Number
  - b) Jack Label
  - c) Wire label
  - d) IDF Room Number
  - e) Rack Label for patch panel
  - f) Patch Panel label
  - g) Patch panel port
  - h) Cable Length
  - i) Data switch rack label (if connected to data switch)
  - j) Data switch label (if connected to data switch)
  - k) Data switch port number (if connected to data switch)

##### B. Copper (Twisted Pair) Testing

1. Copper Cat 6A Installation: field test requirements upon completion of the installation
  - a) General Requirements (Category 6A)
    - 1) Every cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA/EIA-568B-2.10 “*Transmission Performance Specifications for 4-pair 100Ω*

*Category 6A Cabling*". This document will be referred to as the "TIA Cat 6A Standard."

- 2) The installed twisted-pair horizontal links shall be tested from the MDF/IDF (ER/TR) in the telecommunications room to the telecommunication wall outlet in the work area against the "*Permanent Link*" performance limits specification as defined in the TIA Cat 6A Standard.
  - 3) One hundred percent of the installed cabling links must be tested and must pass the requirements of the standards mentioned above and as further detailed in Part 3. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation (below).
- b) Qualifications
- 1) Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. Appropriate training programs include but are not limited to installation certification programs provided by BiCSi or the ACP (Association of Cabling Professionals).
- c) Coordination/Verification:
- 1) **A representative of the Owner shall be invited to witness field testing. The representative shall be notified of the start date of the testing phase five business days before testing commences.**
  - 2) A representative of the Owner may elect to select a random sample of 5% of the installed links. The representative (or his authorized delegate) shall test these randomly selected links and the results are to be stored in accordance with the prescriptions in Section A.3. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the end-user representative ***shall repeat 100% testing and the cost shall be borne by the installation contractor.***

## C. FIBER OPTIC Testing

### 1. GENERAL

- a) The testing Tier shall be as indicated on the Detail Drawings.
  - 1) Testing Tiers requirements are as described below.
  - 2) If not otherwise noted:
    - i) All fiber optic Intra-Building Links shall be tested as Tier 1.
    - ii) All fiber optic Inter-Building Links shall be tested as Tier 2.
- b) Every fiber optic cabling link in the installation shall be tested in accordance with the field test specifications defined by the Telecommunications

Industry Association (TIA) standards ANSI/TIA/EIA-568-C.1, *“Commercial Building Telecommunications Cabling Standard, Part 1, General Requirements,”* and TIA/EIA TSB140, *“Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems.”*

- c) ANSI/TIA/EIA-568-B.1, defines the passive cabling network, to include cable, connectors, and splices (if present), between two optical fiber patch panels (connecting hardware). The test does not, however, include the performance of the connector at the interface with the test equipment.
  - d) 100% of the installed cabling links must be tested and must pass the requirements as specified within this document. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance Part 3.
  - e) The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests in Part 3.
  - f) A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.
2. Qualifications
- a) Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization.
    - 1) Manufacturer of the fiber optic cable and/or the fiber optic connectors.
    - 2) Manufacturer of the test equipment used for the field certification.
    - 3) Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida; ACP [Association of Cabling Professionals™] Cabling Business Institute located in Dallas, Texas)
3. Coordination/Verification
- a) The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.
    - 1) **The Owner or the Owner’s representative shall be notified of the start date of the testing phase five (5) business days before testing commences.**
    - 2) The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail

determination, *the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.*

- 3) All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode and singlemode links and channels and OTDR traces and event tables for multimode and singlemode links and channels.
4. Acceptance of test results.
  - a) Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:
    - 1) Optical loss testing
      - i) Backbone (multimode and singlemode) link
        - (A) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA-568-B.1.
          - (1) Link Attenuation (dB) = Cable\_Attn (dB) + Connector\_Attn (dB) + Splice\_Attn (dB)
          - (2) Cable\_Attn (dB) = Attenuation\_Coefficient (dB/km) \* Length (Km)
          - (3) Connector\_Attn (dB) = number\_of\_connector\_pairs \* connector\_loss (dB)
          - (4) Maximum allowable connector\_loss = 0.75 dB
          - (5) Splice\_Attn (dB) = number\_of\_splices \* splice\_loss (dB)
          - (6) Maximum allowable splice\_loss = 0.3 dB
          - (7) The values for the Attenuation\_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 $\mu$ m	850	3.5	1300	1.5
Multimode 50/125 $\mu$ m	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

- ii) Horizontal (multimode) link
  - (A) The acceptable link attenuation for a multimode horizontal optical fiber cabling system is based on the maximum 90 m (295 ft) distance.
  - (B) The horizontal link may be tested using a fixed upper limit for attenuation of 2.0 dB. This value is based on the loss of two (2) connector pairs, one pair at the telecommunications outlet/connector and one pair at the horizontal cross-connect, plus 90 m (295 ft) of optical fiber cable.

- (C) A horizontal link in an Open Office Cabling network with a consolidation point may be tested using a fixed upper limit for attenuation of 2.75 dB.
  - iii) Centralized (multimode) link
    - (A) The acceptable link attenuation for a multimode centralized optical fiber cabling system is based on the maximum 300 m (984 ft) distance.
    - (B) The centralized link may be tested using a fixed upper limit for attenuation of 3.3 dB. This value is based on the loss of three (3) connector pairs, one pair at the telecommunications outlet/connector, one pair at the consolidation point and one pair at the horizontal cross-connect, plus 300 m (984 ft) of optical fiber cable.
    - (C) A horizontal link in an Open Office Cabling network with a consolidation point may be tested using a fixed upper limit for attenuation of 4.1 dB.
- 2) OTDR testing
  - i) Reflective events (connections) shall not exceed 0.75 dB.
  - ii) Non-reflective events (splices) shall not exceed 0.3 dB.
- 3) Magnified endface inspection
  - i) Fiber connections shall be visually inspected for endface quality.
  - ii) Scratched, pitted or dirty connectors shall be diagnosed and corrected.
- b) All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.
- c) Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

## 1.5 SUBMITTALS

### A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
2. Samples shall be submitted with or immediately following submission of Product Data submittals.

### B. Equipment Data

1. Manufacture datasheets for all twisted pair test equipment

2. Manufacturers datasheets for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and inspection scope as applicable.
- C. Quality Assurance / Control Submittals
1. RCDD Certification for the staff member responsible for this project.
  2. Resume of the last 10 projects of the RCDD responsible for this project
  3. BICSI Technician's certificate for each lead Technician(s) on the project
- D. Closeout Submittal
1. Copper (Twisted Pair) Test Result Documentation
    - a) The test result information for each link shall be recorded in the memory of the field tester upon completion of the test.
    - b) The test result records saved by the tester shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that these results are transferred to the PC unaltered, i.e., "as saved in the tester" at the end of each test. The popular 'csv' format (comma separated value format) does not provide adequate protection and shall not be acceptable unless specified by the end user.
    - c) The database for the completed job, including twisted-pair copper cabling links if applicable, shall be stored and delivered on USB flash drive. This USB flash drive shall include the software tools required to view, inspect, and print any selection of test reports.
    - d) Circuit IDs reported by the test instrument shall match the specified label ID.
    - e) A copy of the test results shall be provided that lists all the links that have been tested with the following summary information. The copy may be delivered on paper or electronically as specified by the end user.
      - 1) The identification of the link in accordance with the naming convention defined in the overall system documentation
      - 2) The overall Pass/Fail evaluation of the link-under-test
      - 3) The date and time the test results were saved in the memory of the tester
    - f) General Information to be provided in the electronic data base containing the test result information for each link:
      - 1) The identification of the customer site as specified by the end-user
      - 2) The overall Pass/Fail evaluation of the link-under-test
      - 3) The name of the standard selected to execute the stored test results
      - 4) The value of the NVP of the cable installed; used for length calculations
      - 5) The date and time the test results were saved in the memory of the tester
      - 6) The brand name, model and serial number of the tester

- 7) The revision of the tester software and the revision of the test standards database in the tester
- g) The detailed test results data to be provided in the electronic database for each tested link must contain the information as set forth in Part 3.
- 2. Fiber Optic Test Result Documentation
  - a) The OLTS and OTDR test result information for each link shall be recorded in the memory of the field tester upon completion of the test.
  - b) The test result records saved by the tester shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that these results are transferred to the PC unaltered, i.e., “as saved in the tester” at the end of each test. The popular ‘csv’ format (comma separated value format) does not provide adequate protection and shall not be acceptable unless specified by the end user.
  - c) The database for the completed job, including twisted-pair copper cabling links if applicable, shall be stored and delivered on USB flash drive. This USB flash drive shall include the software tools required to view, inspect, and print any selection of test reports.
  - d) Circuit IDs reported by the test instrument shall match the specified label ID.
  - e) A copy of the test results shall be provided that lists all the links that have been tested with the following summary information. The copy may be delivered on paper or electronically as specified by the end user.
    - 1) The identification of the link in accordance with the naming convention defined in the overall system documentation
    - 2) The overall Pass/Fail evaluation of the link-under-test
    - 3) The date and time the test results were saved in the memory of the tester
  - f) General Information to be provided in the electronic data base containing the test result information for each link:
    - 1) The identification of the customer site as specified by the end-user
    - 2) The overall Pass/Fail evaluation of the link-under-test
    - 3) The name of the standard selected to execute the stored test results
    - 4) The value of the ‘index of refraction’ used for length calculations
    - 5) The date and time the test results were saved in the memory of the tester
    - 6) The brand name, model and serial number of the tester
    - 7) The revision of the tester software and the revision of the test standards database in the tester
  - g) The detailed test results data to be provided in the electronic database for each tested optical fiber must contain the following information
    - 1) The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation
    - 2) Tier 1:

- (A) The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).
  - (B) The link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas above.
- 3) Tier 2:
    - i) All Tier 1 test results.
    - ii) The overall OTDR loss (attenuation) and length.
    - iii) The OTDR event loss at each wavelength and event location.
    - iv) The OTDR trace at each wavelength.
  - 4) Tier 3:
    - i) All Tier 1 and 2 test results.
    - ii) A picture of the magnified connector endface.
    - iii) The pass status based upon visual inspection.

## **PART 2 PRODUCTS**

### **A. Copper (Twisted Pair) Test Equipment**

#### **1. Category 6A Compliance**

- a) The test equipment (tester) shall comply with the accuracy requirements for level III field testers as defined in the TIA Cat 6A Document. The tester including the appropriate interface adapter must meet the specified accuracy requirements. The accuracy requirements for the permanent link test configuration (baseline accuracy *plus* adapter contribution) are specified in Table B.2.10 of the TIA Cat 6A Standard.
- b) The test plug shall fall within the values specified in E.3.2.2 Modular test plug NEXT loss requirements of the TIA Cat 6A Standard.
- c) The tester shall be within the calibration period recommended by the vendor in order to achieve the vendor-specified measurement accuracy.
- d) The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester interface adapters. In order to deliver optimum accuracy, preference is given to a permanent link interface adapter for the tester that can be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface. The contractor shall provide proof that the interface has been calibrated within the period recommended by the vendor. To ensure that normal handling on the job does not cause measurable Return Loss change, the adapter cord cable shall not be of twisted-pair construction.
- e) The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests (detailed in Part 3). Any Fail or Fail\* result yields a Fail for the link-under-test. In order to achieve an overall Pass condition, the results for each individual test parameter must Pass or Pass\*.

- f) A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter. The test result of a parameter shall be marked with an asterisk (\*) when the result is closer to the test limit than the accuracy of the field tester. The field tester manufacturer must provide documentation as an aid to interpret results marked with asterisks.
  - 2. Utilize the appropriate test equipment as manufactured by Datacom Technologies, Fluke, MicroTest, Scope, WaveTek, WireScope or approved equal. Print test results from the test unit used. Documentation shall include meter catalog number, serial number, manufacturer, cable identifier, Equipment Room/Telecommunications Room identifier, cable type, NVP settings, meter readings, test date, calibration information, and operator responsible for tests.
- B. Fiber Optic Test Equipment
- 1. The test equipment shall be within the calibration period recommended by the manufacturer.
  - 2. Fiber optic test jumpers and adapters shall be of high quality and shall not show excessive wear.
  - 3. Optical Loss Test Set (OLTS)
    - a) An OLTS is comprised of two components: an optical light source and an optical power meter. After making a reference measurement, the source and meter are located at opposite ends of the fiber under test. A source and meter may be contained within the same package to enable bi-directional testing without swapping end test equipment.
    - b) Multimode optical fiber light source
      - 1) Provide dual LED light sources with central wavelengths of 850nm ( $\pm 30$ nm) and 1300nm ( $\pm 20$ nm).
      - 2) Output power of -20dB minimum.
      - 3) Shall meet the requirements of ANSI/TIA/EIA-526-14A. The light source shall meet the launch requirements of ANSI/EIA/TIA-455-50B, Method A. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap (as described in clause 11 of ANSI/TIA/EIA-568-B.1) with a Category 1 light source.
    - c) Singlemode optical fiber light source
      - 1) Provide dual laser light sources with central wavelengths of 1310nm ( $\pm 20$ nm) and 1550nm ( $\pm 20$ nm).
      - 2) Output power of -10dB minimum.
      - 3) Shall meet the requirements of ANSI/EIA/TIA-526-7.
    - d) Power Meter
      - 1) Provide 850nm, 1300nm, 1310nm and 1500nm wavelength test capability

- 2) Shall meet the requirements of ANSI/EIA/TIA-526-14A and ANSI/EIA/TIA-526-7.
  - 3) Power measurement uncertainty of  $\pm 0.25$  dB.
  - 4) Store reference power measurement.
  - 5) Save at least 100 results in internal memory.
  - 6) PC interface (serial or USB)
- e) Optional requirements that lead to faster, more efficient testing
  - 1) Dual-wavelength single-adapter light source
  - 2) Dual-fiber automated testing
  - 3) Fiber length measurement using time-of-flight technology
  - 4) Automated loss budget calculation and pass/fail analysis
- f) Optical Time Domain Reflectometer (OTDR)
  - 1) Shall have a bright, color transmissive LCD display with backlight.
  - 2) Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
  - 3) Weight with battery and module of not more than 4.5lb and volume of not more 200in<sup>3</sup>.
  - 4) Internal non-volatile memory and removable memory device with at least 16MB capacity for results storage.
  - 5) Serial and USB ports to transfer data to a PC.
  - 6) Multimode OTDR
    - i) Wavelengths of 850nm ( $\pm 20$ nm) and 1300nm ( $\pm 20$ nm).
    - ii) Event deadzones of 1m maximum at 850nm and 2m maximum at 1300nm.
    - iii) Attenuation deadzones of 6m maximum at 850nm and 15m maximum at 1300nm.
    - iv) Distance range at least 2000m.
    - v) Dynamic range at least 10dB at 850nm and 1300nm.
- g) Optional requirements
  - 1) Integrated OLTS
  - 2) Integrated optical power meter
  - 3) Integrated video microscope
4. Fiber Microscope
  - a) Magnification of 250X or 400X for endface inspection
  - b) Optional requirements
    - 1) Video camera and display showing magnified endface image
    - 2) Camera probe tips permitting inspection through adapters
    - 3) Capability to save image
  - c) Standard of Quality Shall be Westover Scientific

## **PART 3 EXECUTION**

### **3.1 GENERAL**

- A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.
- B. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

### 3.2 COPPER (TWISTED PAIR) TESTING

#### A. General

- 1. Field-test instruments shall have the latest software and firmware installed.
- 2. Link test results from the Test Equipment shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
- 3. Testing shall be performed on each cabling segment (panel to connector or connector to connector).
- 4. Testing of the cabling shall be performed using high-quality test cords of the same Category and manufacturer as the cabling under test.

#### B. Performance Test Parameters (Category 6A)

- 1. The test parameters for Cat 6A are defined in TIA Cat 6A standard, which refers to the ANSI/TIA/EIA-568B-2.10 standard. Test results shall at a minimum show alien attenuation crosstalk ratio far-end (AACRF), alien far-end crosstalk (AFEXT), alien near-end crosstalk (ANEXT), power sum alien attenuation crosstalk ratio far-end (PSAACRF), power sum alien far-end crosstalk (PSAFEXT), and power sum alien near-end crosstalk (PSANEXT).

### 3.3 OPTICAL FIBER CABLE TESTING

#### A. General

- 1. Field-test instruments shall have the latest software and firmware installed.
- 2. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
- 3. Fiber endfaces shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.
  - a) It is preferable that the endface images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.
- 4. Testing shall be performed on each cabling segment (connector to connector).
- 5. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.
- 6. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be

between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

#### B. Performance Test Parameters

1. Three tiers of certification are available that vary in thoroughness of infrastructure analysis.
  - a) Tier 1: optical loss testing
  - b) Tier 2: optical loss and OTDR testing
  - c) Tier 3: optical loss and OTDR testing and magnified endface inspection
2. Tier 3 certification is recommended unless otherwise specified by the end-user.
3. Optical loss testing (Tiers 1, 2 and 3)
  - a) Backbone link: The backbone link shall be tested bi-directionally at both operating wavelengths to account for attenuation deltas associated with wavelength. Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation (Section C.3.iv) shall be used to determine limit (acceptance) values.
    - 1) Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper or the equivalent method.
    - 2) Singlemode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method.
    - 3) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA/EIA standard 568-B
    - 4) Link Attenuation (dB) = Cable\_Attn (dB)+ Connector\_Attn (dB) + Splice\_Attn (dB)
      - i) Cable\_Attn (dB) = Attenuation\_Coefficient (dB/km) \* Length (Km)
      - ii) Connector\_Attn (dB) = number\_of\_connector\_pairs \* connector\_loss (dB)
      - iii) Maximum allowable connector\_loss = 0.75 dB
      - iv) Splice\_Attn (dB) = number\_of\_splices (S) \* splice\_loss (dB)
      - v) Maximum allowable splice\_loss = 0.3 dB
      - vi) The values for the Attenuation\_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km))
Multimode 62.5/125 μm	850	3.5	1300	1.5
Multimode 50/125 μm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

- 5) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
- 6) The above link test limits attenuation are based on the use of the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1; or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.
- b) Horizontal (multimode) link: The acceptable link attenuation for a multimode horizontal optical fiber cabling system is based on the maximum 90 m (295 ft) distance. The horizontal optical fiber cabling link segments need to be tested at only one (1) wavelength. Because of the short length of cabling, attenuation deltas due to wavelength are insignificant. The horizontal link should be tested at 850 nm *or* 1300 nm in one direction in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper method.
  - 1) The horizontal link may be tested using a fixed upper limit for attenuation of 2.0 dB. This value is based on the loss of two (2) connector pairs, one pair at the telecommunications outlet/connector and one pair at the horizontal cross-connect, plus 90 m (295 ft) of optical fiber cable.
  - 2) A horizontal link in an Open Office Cabling network with a consolidation point may be tested using a fixed upper limit for attenuation of 2.75 dB.
- c) Centralized (multimode) link: The acceptable link attenuation for a multimode centralized optical fiber cabling system is based on the maximum 300 m (984 ft) distance. The centralized optical fiber cabling link segments need to be tested at only (1) wavelength. Because of the short length of cabling, attenuation deltas due to wavelength are insignificant. The horizontal link should be tested at 850 nm *or* 1300 nm in one direction in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper method. Testing at 850 nm is recommended unless otherwise specified by the end user.
  - 1) The centralized link may be tested using a fixed upper limit for attenuation of 3.3 dB. This value is based on the loss of three (3) connector pairs, one pair at the telecommunications outlet/connector, one pair at the consolidation point and one pair at the horizontal cross-connect, plus 300 m (984 ft) of optical fiber cable.
  - 2) A horizontal link in an Open Office Cabling network with a consolidation point may be tested using a fixed upper limit for attenuation of 4.1 dB.
- d) Optional requirements:

- 1) Each horizontal and centralized link shall be tested bi-directionally since the direction of the signal transmission often cannot be predicted at the time of installation. This is especially true for non-polarized connectors.
  - 2) Each horizontal and centralized link shall be tested at both 850nm and 1300nm to confirm no attenuation differences due to wavelength even over short links.
4. OTDR Testing (Tiers 2 and 3).
  - a) Backbone, horizontal and centralized links shall be tested at the appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
    - 1) Backbone multimode: 850nm and 1300nm
    - 2) Backbone singlemode: 1310nm and 1550nm
    - 3) Horizontal multimode: 850nm or 1300nm
    - 4) Centralized multimode: 850nm or 1300nm (850nm recommended unless otherwise specified by the end user)
  - b) Each fiber link and channel shall be tested in one direction.
  - c) A launch cable shall be installed between the OTDR and the first link connection. The launch cable shall be approximately 100m (328ft) in length and of the same fiber type as the link under test.
  - d) A receive cable shall be installed after the last link connection. The receive cable shall be at least 25m (82ft) in length and of the same fiber type as the link under test.
  - e) Reflective events (connections) exceeding 0.75 dB shall be identified, recorded and remedied to be less than 0.75 dB.
  - f) Non-reflective events exceeding 0.3 dB shall be identified recorded and remedied to be less than 0.3 dB. . Non-reflective events shall only be accepted for splices along the cabling. There shall be no losses acceptable for cable bends.
  - g) Optional requirements
    - 1) Bi-directional link testing.
    - 2) Segment attenuation coefficient if segment length > 1000m (3280ft). The segment attenuation coefficient shall not exceed 3.5 dB/km at 850nm and 1.5 dB at 1300 dB. Fibers exceeding these attenuation coefficients shall be replaced.
5. Magnified Endface Inspection (Tier 3)
  - a) Fiber connections shall be visually inspected for endface quality. High loss and reflectance can result from improperly terminated, poorly polished or dirty connectors.

- b) Fibers shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers.
- c) Scratched, pitted or dirty connectors shall be diagnosed and corrected.
- d) Optional requirements
  - 1) The endface image shall be saved and included in the test documentation package.
- 6. Length Measurement
  - a) The length of each fiber shall be recorded.
  - b) It is preferable that the optical length be measured using an OLTS or OTDR.
- 7. Polarity Testing
  - a) Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with subclause 10.3 of ANSI/TIA/EIA-568-B.1. The polarity of the paired duplex fibers shall be verified using an OLTS.
- C. Performance Test Parameters (OSP Cable)
  - 1. Campus Backbone OSP Fiber Optic cable testing.
    - a) Fiber optic cabling: Test all fiber optic cabling completely in accordance with ANSI/TIA/EIA-568-A, Annex H.
      - 1) All fibers shall be proof tested by the manufacturer at a minimum load of 6000 kPa. All fibers shall be 100 percent attenuation tested by the manufacturer for compliance with the specified performance requirements. Provide manufacturer's test results and performance certification before installation.
      - 2) Perform 100 percent attenuation test on all fiber optic cabling on the reel after receipt and before installation. Submit results to Owner for comparison against manufacturer's certified test results.
      - 3) If any test results fail to meet the manufacturer's certified test results or are non-compliant with this Section, the cable shall be rejected.
      - 4) Test and document all fiber optic cables from both ends on each terminated strand with a properly calibrated Optical Time Domain Reflectometer (OTDR) as manufactured by Sietec or approved equal. Documentation shall include OTDR catalog number, serial number, manufacturer, strand identifier, meter readings, test date, calibration information, and operator responsible for tests. All OTDR testing shall be fully compliant with ANSI/EIA/TIA-455-8.
      - 5) Provide 100 meters of like fiber to project OTDR cable examination beyond the "dead zone."
      - 6) Test and record all fiber losses and submit to Owner for approval. Provide all test information on printouts and on electronic files. Perform test as segments of the fiber installation are completed and as directed by the Owner

**END OF SECTION 27 08 10**

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## COMMUNICATIONS ROOM WALL LININGS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Supply and installation of Communications Backboard wall linings used for Communications, Life Safety and Security equipment mounting within Equipment Room(s) <ER>, Building Distribution Frame <BDF>, Entrance Facility <EF>, Telecommunications Room(s) <TR> and other spaces indicated on related drawings.
  - 2. System includes but is not limited to:
    - a) Backboards.
- B. Related Sections
  - 1. All Division 27 Sections
  - 2. Common Work Results
    - a) Division 27 – “Basic Materials and Methods”
    - b) Division 27 – “Grounding and Bonding for Communications Systems”
    - c) Division 27 - “Pathways for Communications Systems”.
    - d) Division 27 – “Identification for Communications Systems”
  - 3. Interrelated Sections
    - a) None
- C. Related Drawings
  - 1. Technology (T-Series) Drawings
- D. Definitions
  - 1. Communications Backboard – Also referred to as Telecommunications Backboard (TBB).

#### 1.3 REFERENCES REFERENCES

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- D. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- E. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 DEFINITIONS

- A. Communications Backboards (Also Telecommunications Backboards) are utilized to line the walls of Equipment or Telecommunications Rooms for equipment mounting purposes.

#### 1.5 SYSTEM DESCRIPTION /DESCRIPTION OF WORK

- A. Provide Communications backboards in all rooms or spaces as indicated on the Detail Drawings.
  - 1. All usable walls in Equipment and Telecommunications rooms shall be lined with Communications Backboards.
  - 2. All wall mounted Cabinets/racks shall be mounted on a Communications Backboard.
  - 3. All wall mounted equipment shall be mounted on a Communications Backboard (i.e. Building Entrance Facility, etc.)
  - 4. Other rooms and spaces as noted on the related drawings

#### 1.6 SUBMITTALS

- A. General
  - 1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
  - 2. Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Close-Out Documentation
  - 1. MSDS sheet for fire retardant paint.

### **PART 2 PRODUCTS**

#### 2.1 PRODUCT STANDARDS

- A. Communications Backboards
  - 1. Shop or field-fabricated 4' by 8' plywood backboards.
    - a)  $\frac{3}{4}$ " AC-grade plywood with 2 coats of white fire-retardant paint. (Do not use fire-retardant treated plywood.)

- b) Mount with A grade finish outward.
- c) Paint all edges.
- B. Labels
  - a) Communications Backboards
    - 1) Label shall be white polyester.
    - 2) Label shall have temperature range of -40 to 248 degrees F
    - 3) Label shall have superior adhesion and utilize thermal transfer
    - 4) Label shall utilize ¾" black font
    - 5) Standard of quality shall be Brady PTL-100-483

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

##### **A. Communications Backboards**

1. Provide and properly secure plywood backboard(s) in each Equipment Room and Telecomm/Telecommunications Room.
2. All hardware to secure backboard shall be flush and smooth. Do not allow hardware to stand off of the surface of plywood.
3. Communications backboards shall be assembled from 4' wide by 8' tall materials.
4. Attached plywood to the wall in the positions as shown drawings.
5. Each backboard shall be mounted use horizontally arrayed columns of three or more bolts (top, middle, and bottom). Columns of bolts shall be spaced so as to secure the backboard directly to wall studs or other structural wall members. Each full-size sheet or plywood shall be supported with a minimum of 3 columns of bolts. Horizontal spacing of bolts shall not exceed 24 inches.
6. Backboards shall be mounted with the bottom edge square and level ¼" above the baseboard or 6" above finished floor (whichever is lower).
7. Where a full size backboard cannot be utilized, a standard backboard shall be cut to fit the space. All edges shall be re-painted.
8. Where backboards are mounted over devices (such as switches and outlets) the backboard shall be cut to permit the entire device to be revealed plus and additional ¼" trim space on each side.
9. Each backboard shall be labeled to correspond to the backboards shown on the detail sheets.

**END OF SECTION 27 11 11**

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## COMMUNICATION CABINETS, RACKS, FRAMES, AND ENCLOSURES

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

##### A. Section Includes:

- 1. Supply and installation of a complete hardware systems for
  - a) Equipment racks, cabinets, frames, enclosures and related accessories.
  - b) Equipment rack labeling
  - c) Ceiling enclosures (Zone Cabling) (**\*Only to be used if specifically requested by Owner.**)
- 2. System includes but is not limited to:
  - a) Cabinets
  - b) Racks
  - c) Hardware
  - d) Accessories

##### B. Related Sections

- 1. All Division 27 Sections
- 2. Common Work Results
  - a) Division 27 – “Operation and Maintenance of Structured Cabling and Enclosures”
  - b) Division 27 – “Basic Materials and Methods”
  - c) Division 27 – “Grounding and Bonding for Communications Systems”
  - d) Division 27 – “Pathways for Communications Systems”.
  - e) Division 27 – “Identification for Communications Systems”
- 3. Interrelated Sections
  - a) Division 27 – “Communications Cable Management and Ladder Rack”

##### C. Related Drawings

- 1. Technology (T-Series) Drawings

##### D. Special Requirements

1. All products furnished of a given type under this section shall be manufactured by a single manufacturer; shall bear the same brand name; shall be of the same finish color and texture; and shall be from the same product model series, unless otherwise noted.
2. The Contractor/sub-contractor(s) providing work of this section shall coordinate with all other Contractors/sub-contractors supplying work within the equipment racks. This coordination shall include review of equipment rack configurations to ensure that they appropriately complement the systems specified; and shall include the delivery of product and installation to meet the workflow of sub-contractors and the project as a whole.
3. This contractor shall coordinate the delivery and timing of delivery of equipment racks to the project site and/or project site as mutually agreed upon with each individual sub-contractor.
4. ***Contractor shall coordinate any rack layout and placement of any enclosure in any room with Owner before any equipment is installed. Contractor shall also coordinate layout of equipment to be installed in to racks with Owner before any equipment is installed or any cables are cut to termination length.***

### 1.3 REFERENCES

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- D. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- E. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

### 1.4 GENERAL INFORMATION

#### A. Definitions

1. The term “Equipment Rack”, or “Rack”, in either it’s singular or plural form, as utilized within this specification(s) and on the drawings is intended to generically refer to products designed for and normally used to house and/or mount 19”, 23” and 25” E.I.A. standard “rack mounted” equipment. These “Racks” come in multiple forms, sizes, styles and finishes including but not limited to the following:
  - a) Cabinet Types
  - b) Open Frame/Relay Types
  - c) In-Wall Types
  - d) Wall Mounted Types

- e) Swinging Types
  - f) Portable and Roll around Types
  - g) ATA Types
  - h) Miscellaneous specialty types
2. Where brackets are used around numbers or letters within this section ((examples: [nn] and [xx])), they represent alphanumeric variables. Often these variables represent that portion of a model number that must be established by the contractor when ordering product based upon the size, color or other information furnished within these specifications and/or noted on the related drawings.

#### 1.5 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. Furnish and install all Equipment Racks (see “Definitions”), accessories and products identified in this section, and as shown on the Drawings, and as additionally required to support the installation of systems and equipment specified in other related sections.
- B. Mount securely as specified and shown.
  - 1. Coordinate with the Construction Manager for resolution of any deviations, defects, or other problems with the planned pathway or spaces prior to installation; allow adequate time for corrections so as to avoid delays to the target completion date.
- C. Provide all rack hardware and accessories as specified.
  - 1. Refer to drawings for additional rack accessories to be provided.
  - 2. All accessories shall be of the same manufacture as the Rack unless otherwise noted.
- D. Label all equipment racks in accordance with Section – “Identification For Communications Systems”.

#### 1.6 SUBMITTALS

- A. General
  - 1. Product Data shall be submitted as a single submittal.
  - 2. Samples requested shall be submitted with or immediately following submission of Product Data submittals.
- B. Product Data
  - 1. Complete Bill of Materials (BOM) List
    - a) The BOM shall be organized (i.e. “sub-grouped”) by Device ID.
    - b) Under each Device ID the Contractor shall enumerate the brand and model of every product to be supplied associated with each Device ID.
    - c) The manufacturer’s name (Brand) and full model number shall be used. (Distributor and Contractor assigned names and model numbers are unacceptable).
    - d) Adjacent to the Device ID the Contractor shall clearly indicate the following:
      - 1) The Rack Type (as identified within these specifications)

- 2) The room name and number in which the rack is to be located.
    - 3) The system(s) that the rack supports
  2. Manufacturer Product Datasheet for each product.
    - a) Product datasheets shall be manufacturer originals, or first generation printed versions of manufacturer's official electronic product sheets.
    - b) Manufacture model shall be highlighted on each sheet.
    - c) Datasheets shall be organized to match the order and organization of this section
- C. Shop Drawings
  1. Shop Drawings required for any changes to the Bid Documents.
  2. ½" = 1'0" Enlarged Floor Plans of each space that houses one or more equipment rack(s) or related accessory product.
    - a) Drawings shall be reproduced on 11" x 17" paper,
      - 1) Drawings shall be reinforced, folded and bound into the rear of the submittal binder.
      - 2) Each drawing shall reflect a single room.
    - b) Drawings shall clearly reflect the unique Device ID assigned to the rack.
  3. Full Scale drawings of the labels that will be affixed to each equipment racks.
- D. Closeout Submittals
  1. Communication Room enlarged Floorplan Layouts, drawing to scale, depicting device sizes and locations..
  2. A diagram of the labeling scheme used on the Project.

## **PART 2 PRODUCTS**

### **2.1 PRODUCTS**

#### **A. General**

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not listed in Part 2, will be evaluated as a performance specification based on the information provided on the Drawings.

### **2.2 EQUIPMENT RACKS**

#### **A. General**

1. Alternate equipment racks may not exceed the physical dimensions of the specified equipment racks, nor may they be less than ½ inches less in any external dimension without the model specific pre-bid written approval of the Designer.

2. All racks shall be UL Listed for the location and manner in which the product will be installed and used.
3. All equipment racks and their accessories shall be furnished black in color unless otherwise expressly identified herein or noted on the drawings.
4. All racks supplied of a given type shall be as manufactured from a single manufacturer; bare the same brand name; and shall be from the same model series.
5. All racks located adjacent to one another shall be matching in size, color, fit and finish texture, and shall be manufactured by the same manufacturer except where otherwise expressly required by the Designer.
6. All racks located within eye-sight of one another shall be matching in color, finish texture, and as manufactured by the same manufacture except where otherwise expressly required by the Designer.

**B. Open Types**

1. Type R1 -
  - a) Free standing open frame relay rack;
  - b) 77 - 78-3/4" of usable vertical panel space
  - c) 19 inch EIA horizontal rack rail spacing
  - d) 24" wide
  - e) Drilled and tapped rack mounting rails with #10-32 mounting holes.
    - 1) 12/24 mounting screw option shall include 100 12/24 screws
  - f) Matching accessory support base
  - g) Standard of quality: Panduit R2P
    - 1) See Chart below for required accessories:
  - h) Additional approved manufacturer(s): Great Lakes Case & Cabinet

RACK TYPE:	<b>R1</b>	
	<i>Standard of Quality</i>	<i>Additional approved Manufacturer</i>
Manufacturer:	PANDUIT	GREAT LAKES CASE & CABINET
H/W Inches:	84/25	84/24.94
Usable RU:	45	45

Screw Type:	Phillips 12/24	Phillips 12/24
Rack:	R2P	GLRR-1984BA
Vert.Cable Mgmt		
Rails:	INCL	INCL
Front Cord Rings:	INCL	INCL
Busbar:	TRGB19	CBB-72
Screws	INCL	(2) HDW-104-50

C. Specialty Types

1. Type X1

- a) Consolidation Point Enclosure (**\*Only to be used if specifically requested by Owner.\***)
  - 1) In-Ceiling (plenum rated) zone cabling box.
  - 2) Box must fit in 2' by 2' ceiling tile grid; 23.5" by 23.5" by 12.13" deep enclosure.
  - 3) Must provide at least 3 RU of panel mounting space for active electronics up to 15.5" deep.
  - 4) Must provide at least 6 RU of panel mounting space for 19" standard passive connectivity.
  - 5) Must be supplied with enclosure, doorplate, equipment mounting bracket, plenum rating kit, and a fan unit.
  - 6) Standard of quality shall be Panduit CICZC2X2A
  - 7) Additional approved manufacturers: Middle Atlantic, Hubbell, Hoffman, X-Mark

2.3 LABELS

1. Equipment Racks

- a) Label shall be white polyester.
- b) Label shall have temperature range of -40 to 248 degrees F
- c) Label shall have superior adhesion and utilize thermal transfer
- d) Label shall utilize ¾" black font
  - 1) Standard of quality shall be Brady PTL-100-483

## PART 3 EXECUTION

### 3.1 GENERAL

- A. Secure all fixed position, non-portable equipment racks using removable threaded fasteners to prevent equipment racks from movement and tipping over.
- B. Bond all equipment racks to the Telecommunications System Ground.
- C. Properly secure racks to the floor allowing a minimum of 60-inches of clearance from the rear of the rack to the rear wall and 48-inches of clearance from the front of the

rack to the front wall unless otherwise expressly dimensioned on drawings and approved in writing by Owner.

### 3.2 EQUIPMENT RACKS

#### A. Cabinet Types

1. Install bushings or grommets to protect cables where exiting or entering the rack. Clean, prep and paint visible conduits using oil-based paint that exactly matches color of equipment rack.

#### B. Open Frame/Relay Types

1. Install bushings or grommets to protect cables where exiting or entering the rack. Clean, prep and paint visible conduits using oil-based paint that exactly matches color of equipment rack.

#### C. Swinging Cabinet Types

1. Furnish and install minimum of two (2) 3-inch conduits stubs from top of cabinet back pan to cable tray, ladder rack and/or accessible ceiling above for cabling. Provide additional quantities and sizes as indicated on drawings. Install insulated throat bushings to protect cables. Clean, prep and paint visible conduits using oil-based paint that exactly matches color of equipment rack.

#### D. Wall Mounted Types

1. Furnish and install minimum of two (2) 3-inch conduits stubs from top of cabinet to cable tray, ladder rack and/or accessible ceiling above for cabling. Provide additional quantities and sizes as indicated on drawings. Install insulated throat bushings to protect cables. Clean, prep and paint visible conduits using oil-based paint that exactly matches color of equipment rack.

### 3.3 IN-CEILING ZONE CABLING ENCLOSURES (\* ONLY TO BE USED IF SPECIFICALLY REQUESTED BY OWNER.)

- A. In-ceiling consolidation points shall be designed to fit in 2'x2' drop-ceiling grid.
- B. Enclosure shall be supported from building structure above lay-in ceiling grid and be installed to manufacturer's instructions.
- C. Enclosure shall be capable of mounting at least 3 RU of electronic equipment and 6 RU of panel space.

### 3.4 RACK ACCESSORIES

#### A. Rack Lights

1. Supply and mount service lights in the rear of all equipment racks.
2. Where non-magnetic racks are supplied, supply and install Designer approved alternate fixture attachment hardware.

#### B. Filler Panels

1. Coordinate the required size, type and location of all filler panels directly with the suppliers of the systems and equipment to be housed within equipment racks.

The size, location and ratio of blank-to-vent filler panels shall be as required to assure proper ventilation of equipment.

2. Mount the filler panels within the rack using approved mounting hardware, ensuring that all unused spaces within the equipment rack are covered.

### 3.5 LABELING

#### A. Label each equipment rack uniquely using specified labels.

1. Clean surface(s) prior to application of label.
2. Labels shall:
  - a) Be 4" Wide x 1.3" High;
  - b) Use ¾" high capital letters
  - c) White background
  - d) Black lettering
3. Labeling of racks shall be as designated on the drawings. Where not shown on the drawings, the Contractor shall submit its proposed labeling scheme for review, comment and approval prior to fabrication and installation of labels.
4. In multi-bay gangable equipment rack arrays, racks shall be labeled with sequential numbers from left-to-right when facing the front of the cabinets unless otherwise indicated on the Drawings.

**END OF SECTION 27 11 16**

## **COMMUNICATION CABLE MANAGEMENT AND LADDER RACK**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Wire Management panels for all Technology System Racks/Cabinets.
  - 2. All cable support required within the Equipment Room (ER) and each Telecommunications Room (TR) shall be provided under this Section.
  - 3. Special requirements are as noted on Drawings.
  - 4. All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.
- B. Related Sections
  - 1. Common Work Results
    - a) Division 27 – “Basic Materials and Methods”
    - b) Division 27 – “Grounding and Bonding for Communications Systems”
    - c) Division 27 - “Pathways for Communications Systems”.
  - 2. Interrelated Sections
    - a) Division 27 – “Communications Cabinets, Racks, Frames and Enclosures”
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### **1.3 REFERENCES**

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- D. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- E. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### **1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK**

A. Main Equipment Room <ER>/<BDF>, Telecommunications Room (TR) and Communications space requirements.

1. General:

- a) The Main Equipment Room (ER)/<BDF> and the Telecommunications Rooms (TRs) will be located as indicated on the Drawings.
- b) Other spaces used for Communications equipment shall be as indicated on the Drawings

2. BDF/ER/TR and Communications Space Requirements

- a) Provide all wire management and blank panels as shown on the Detail Drawings for each equipment rack/cabinet in the Project.
  - 1) Utilize detail sketches for quantities and positioning:
- b) Provide ladder rack for all telecommunications cabling in the ER/TR(s) as shown on the detail drawings.
  - 1) Fill capacity (as designated by the manufacturer) shall not be exceeded;
  - 2) Utilize properly sized supports with adequate strength to exceed the maximum recommended weight capacity.
  - 3) Ladder rack minimum requirements are as shown on the Detail Drawings
- c) Provide and secure ladder rack for cable support for Technology Systems
  - 1) Technology systems include but are not limited to:
    - i) Voice/Telephone Systems
    - ii) Network/Data Systems
    - iii) RF Broadband Video Distribution Systems
    - iv) Intercom and Central Sound Systems
    - v) Paging and Sound Masking Systems
    - vi) Security Systems including CCTV, Access Control, Intrusion Detection Systems
    - vii) Sound Reinforcement Systems
    - viii) Audio-Visual Systems
    - ix) Teleconferencing Systems
- d) The Contractor shall verify the pathway being provided by others prior to installation to assure inter-operability. (i.e. ladder rack aligns with sleeves and racks/cabinets.)
  - 1) Coordinate with the Construction Manager for resolution of any deviations, defects, or other problems with the pathway prior to installation; allow adequate time for corrections so as to avoid delays to the target completion date.

1.5 SUBMITTALS

A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
  2. Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Items to be submitted for approval prior to commencement of work:
1. Product Data
    - a) Manufacture datasheets for all equipment
      - 1) Data sheets shall include
        - i) Manufacturer name
        - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
        - iii) Manufacturer product description
        - iv) Paragraph number of this section where the product is specified.
        - v) Picture or Drawing of item
- C. Shop Drawings required if different than Bid Documents.
1. Plan Drawing(s)
    - a) Depicting the location of all ladder rack.
  2. Equipment Rack Elevations
    - a) Scaled
    - b) Depicting the locations of all system products installed within the rack, coordinated with work of other sections, as applicable.
- D. Quality Assurance / Control Submittals
1. RCDD Certification for the staff member responsible for this project.
  2. Resume of the last 10 projects of the RCDD responsible for this project
  3. BICSI Technician's certificate for each lead Technician(s) on the project
- E. Closeout Submittal
1. Communication Room Rack Layouts, drawing to scaled, depicting devices and rack space occupied by each installed component, coordinated with work of other sections, as applicable.

## **PART 2 PRODUCTS**

### **2.1 PRODUCT STANDARDS**

A. General

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not listed in Part 2, will be evaluated as a performance specification based on the information provided on the Drawings.

B. Ladder rack:

1. Horizontally mounted

- a) Provide cable support ladder rack in Equipment Room/Telecommunications Room as indicated in the Contract Documents.
  - 1) Ladder rack shall be constructed of 1 ½ inch by 3/8 inch ASTM A513 compliant tubular steel
  - 2) Black in color.
  - 3) Ladder rack dimensions shall be 12 to 24 inches wide (as indicated on the drawings) with 9 to 12 inch spacing between cable support rungs.
  - 4) Ladder installed horizontally shall have 7-inch high posts spaced every 3' on center.
    - i) Include all manufacturer recommended hardware and accessories for a complete unit including, but not limited to, splice extension clamps, horizontal tee splice kits, corner support kits, adjustable vertical bend kits, adjustable vertical splice kits, runway support kits designed for ceiling support from all threaded rod, runway drop-out at equipment racks, runway end caps, etc.
    - ii) Provide waterfall fittings in every location that cable is designed to exit the rack downward at the end of a run or between the rungs.
    - iii) Support with threaded rod and U-channel supports systems (See Accessories, Supporting Devices – Field Fabricated)
  - 5) The ladder rack shall be ceiling supported with wall bracing at rack ends.
  - 6) Standard of quality shall be Chatsworth 10250-712
    - i) Additional approved manufacturers: Cooper/B-Line, Hoffman, Homaco, Middle Atlantic

2. Vertically mounted

- a) Provide cable support ladder rack in Equipment Room/Telecommunications Room as indicated in the Contract Documents.

- 1) Ladder rack shall be constructed of 1 ½ inch by 3/8 inch ASTM A513 compliant tubular steel
    - 2) Ladder rack dimensions shall be 12 to 24 inches wide (as indicated on the drawings) with 9 to 12 inch spacing between cable support rungs.
    - 3) Mount flat to backboard with wall mount clamps.
    - 4) Standard of quality shall be Chatsworth 10250-212
      - i) Additional approved manufacturers: Cooper/B-Line, Hoffman, Homaco, Middle Atlantic
  3. Cable Drop-outs (“Waterfalls”)
    - a) Shall mount securely to ladder rack rails and shall maintain minimum bend radius on all cables entering or exiting the Ladder Rack.
    - b) Standard of quality shall be Chatsworth 12100-xxx.
      - i) Additional approved manufacturers: Cooper/B-Line, Hoffman, Homaco, Middle Atlantic
- C. Wire Management
1. Within Telecommunication Racks
    - a) TYPE A (All wire management panels shall be of this type unless specifically noted as another type on the detail drawings)
      - 1) Wire management panels shall provide station cable routing on the rear and both horizontal and vertical metal slotted rings, and plastic wire holding clips on the front.
      - 2) Full length vertical wire management panels shall be installed between each rack and at both ends of each row of racks.
      - 3) Horizontal wire management standard of quality:
        - i) 2 rack space units (RU):  
(A) Panduit CMPH2
        - ii) 1 rack space units (RU):  
(A) Panduit CMPH1
        - iii) Add with CMVDR2 (2 RU panels) or CMVDR1S (1 RU panels) on each side of each panel unless mounting in a cabinet that has an integral vertical cable management channel.
      - 4) Vertical wire management standard of quality:
        - i) Panduit WMPVHC45E.

## **PART 3 EXECUTION**

### **3.1 GENERAL REQUIREMENTS**

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

### 3.2 INSTALLATION PRACTICES

- A. Standards: The minimum criteria for proper installation can be found in the *TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL* published by the Building Industry Consulting Services International. The vendor must refer to this publication for cable installation practices. This Specification may take exception to optional statements within this manual. Treat any conflict per this Specification under discrepancies or Conflicts.

- B. Equipment Rooms and Telecommunications Rooms and other spaces as indicated:

1. Ladder rack: Provide cable support ladder rack as specified. Provide all manufacturer recommended hardware and accessories including, but not limited to, splice extension clamps, horizontal tee splice kits, corner support kits, adjustable vertical bend kits, adjustable vertical splice kits, runway drop-out at equipment racks, runway end caps, etc. Do not route cabling through the support rungs or the ladder rack in the closets. Attach the ladder rack to the equipment racks.

- C. Ladder rack installation:

1. Horizontally mounted

- a) Ladder rack shall mount approximately 96 1/4" to 102" A.F.F. (top of backboards); unless otherwise noted.
- b) Rack mounted with a side along a backboard, may mount with wall brackets; utilize threaded rod and manufacturer's bracket kits for suspension of all remaining ladder rack sections.
- c) Install as a complete system in accordance with manufacturer's written installation instructions as indicated on the Drawings and to ensure electrical continuity of the system and adequate support for the cabling. Provide all manufacturer's recommended fittings and accessories.
- d) Provide support for the ladder rack at a minimum of 4' 6" on center and at all splices, tees, elbows, bends, intersections, and transitions.
  - 1) Support with threaded rod and U-channel supports systems
    - i) 12" width – 1/2" ATR; 24" width – 5/8" ATR
  - 2) Rod lengths over 6' will require a "Rod Stiffener" installation.
    - i) A section of U-Channel stock is placed around the rod and stiffener clamp assemblies used to clamp to rod
      - (A) Place clamps a minimum of 6" from the top and bottom of the rod and every 18" in between.
- e) Install system free of all sharp edges, burrs or projections.
- f) Ground and bond the system in accordance with the NEC and ANSI/TIA/EIA 607.

- g) Provide side posts at 2' on center to both sides of the rack lengths.
  - h) Provide end caps as specified.
  - i) Route parallel and perpendicular to building surfaces.
  - j) Install "waterfall" type protection for cable exit downward between rungs.
  - k) Paint fittings as required to maintain aesthetic integrity of the installation.
2. Vertically mounted
- a) Ladder rack rails shall mount flush against the backboard with rungs out.
  - b) Rack mounted with one end on the floor and extending to intersecting cable tray/ladder rack used for horizontal cable delivery.
  - c) Install as a complete system in accordance with manufacturer's written installation instructions as indicated on the Drawings and to ensure electrical continuity of the system and adequate support for the cabling. Provide all manufacturer's recommended fittings and accessories.
  - d) Provide support for the ladder rack at a minimum of 3' on center up the entire length.
  - e) Install system free of all sharp edges, burrs or projections.
  - f) Ground and bond the system in accordance with the NEC and ANSI/TIA/EIA 607.
  - g) Provide end caps as specified.
  - h) Route parallel and perpendicular to building surfaces.
  - i) Trim out square slot in ceiling adequate for cable and rack to penetrate above ceiling line (if applicable).
  - j) Paint fittings as required to maintain aesthetic integrity of the installation.
- D. Wire Management
- 1. All rack/cabinet panels shall be securely attached with all recommended screws.
  - 2. Space and position all panels as indicated on the Drawings
    - a) Perform Final Coordination with other specification systems prior to installation.
    - b) No electrical power cords or cables shall run inside data cable raceways.
    - c) Co-ordinate with Owner before installation.

**END OF SECTION 27 11 23**

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## **COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Supply and installation of Uninterruptible Power Supplies housed within or housed external to and used to supply power to products installed within Communications equipment cabinets/rack(s).
  - 2. Supply and installation of AC power distribution and sequencing products housed within equipment racks, cabinets, frames and enclosures.
- B. Related Sections
  - 1. Common Work Results
    - a) Division 27 – “Operation and Maintenance of Structured Cabling and Enclosures”
    - b) Division 27 – “Basic Materials and Methods”
    - c) Division 27 – “Grounding and Bonding for Communications Systems”
  - 2. Interrelated Sections
    - a) Division 27 – “Communications Cabinets, Racks, Frames and Enclosures”
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### **1.3 GENERAL INFORMATION**

- A. Special Requirements
  - 1. All products furnished of a given type under this section shall be manufactured by a single manufacturer; shall bear the same brand name; shall be of the same finish color and texture; and shall be from the same product model series unless otherwise noted and/or approved by the Designer.
  - 2. The Contractor/sub-contractor(s) providing work of this section shall coordinate with all other Contractors/sub-contractor(s) supplying work within equipment racks, cabinets, frames and enclosures. This coordination shall include review of

product configurations to ensure that the appropriately complement the systems specified; and shall include the delivery of product and installation to meet the workflow of the sub-contractors and the project as a whole.

3. This contractor shall coordinate the delivery and timing of delivery of products to the project site as mutually agreed upon with each individual sub-contractor.

#### 1.4 QUALITY ASSURANCE

- A. The Prime Contractor or his subcontractor responsible for this Section shall have a Registered Communications Distribution Designer (RCDD) on staff that will be ultimately responsible for this Project. The RCDD must have sufficient experience in this type project as to be able to lend adequate technical support to the field forces during installation, the warranty period, and any extended warranty periods or maintenance contracts. If in the opinion of the Owner, the RCDD does not possess adequate qualifications to support the Project, the Owner reserves the right to require the Contractor to assign an RCDD who, in the Owner's opinion, possesses the necessary skills and experience required of this Project.
- B. The lead technician(s) on the Project shall carry a current BICSI Technician Certificate or have five years of experience in projects of similar scope.
- C. The lead technician(s) on the Project shall have a thorough understanding of the following:
  1. American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA J-STD-607A Commercial Building Grounding and Bonding Requirements for Telecommunications.
- D. All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.

#### 1.5 SUBMITTALS

- A. General
  1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
  2. Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Items to be submitted for approval prior to commencement of work:
  1. Product Data
    - a) Manufacture datasheets for all equipment

- 1) Data sheets shall include
    - i) Manufacturer name
    - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
    - iii) Manufacturer product description
    - iv) Paragraph number of this section where the product is specified.
    - v) Picture or Drawing of item
  2. Shop Drawings
    - a) System block wiring diagram, detailed.
- C. Shop Drawings
  1. Power Distribution Block Diagram(s)
    - a) Drawings shall depict the specific power products and the exact AC power distribution configuration for each rack.
    - b) Separate power distribution diagrams shall be prepared and submitted for each rack, cabinet enclosure shall be presented on a separate drawing.
      - 1) Where identical power distribution arrangements are being planned to be supplied for multiple racks a typical shall be supplied that clearly identifies every rack (by Device ID) that will be using that specific power distribution plan.
- D. Quality Assurance
  1. RCDD Certification for the staff member responsible for this project.
  2. Resume of the last 10 projects of the RCDD responsible for this project
  3. BICSI Technician's certificate for each lead Technician(s) on the project
- E. Closeout Submittal
  1. Power Distribution Block Diagram(s)
    - a) Drawings shall depict the specific power products and the exact AC power distribution configuration for each rack

## **PART 2 PRODUCTS**

### **2.1 PRODUCT STANDARDS**

#### **A. General**

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not listed in Part 2, will be evaluated as a performance specification based on the information provided on the Drawings.
4. All AC power distribution products and racks shall be UL Listed for the location and manner in which the product will be installed and used.

## 2.2 POWER DISTRIBUTION

### A. General

1. All AC power distribution products shall be UL Listed for the location and manner in which the product will be installed and used.
2. Provide each equipment rack with a horizontal power distribution device, APC part number AP9571A with cord retention bracket Part number AP9569.
3. Provide each ER/TR with an APC UPS Part Number SRT5KXLT.
4. Isolated ground versions of distribution products shall be provided when related drawings indicate the presence of isolated ground circuits serving the equipment. If contractor cannot determine the presence of isolated ground circuits, isolated ground power distribution equipment shall be presumed, and the clarification of the Designer shall be sought and obtained.
5. Furnish receptacles of the amperage rating matching the power feed(s) to the provided UPS.
6. No electric cables or cords shall run inside data raceways.

## PART 3 EXECUTION

### 3.1 GENERAL

#### A. Reserved.

### 3.2 INSTALLATION

#### A. General

1. Secure all fixed position equipment racks using removable threaded fasteners to prevent
  - a) Mount receptacle strips in the rear of a cabinet or on rear of open frame relay racks at ten rack units from bottom of rack.
  - b) When UPS products are present, connect receptacle strips into outlets located on the UPS.

**END OF SECTION 27 11 26**

## **COMMUNICATIONS COPPER BACKBONE CABLING**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Sections for additive information where applicable.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Supply and installation of a complete and working Copper Backbone Cabling Systems for
    - a) Voice / Telephone
      - 1) Including Data connectivity provisions for Other Systems (i.e. Video Surveillance, Access Control, Control Data, Intrusion Detection, etc.).
  - 2. System includes but is not limited to:
    - a) Backbone cabling.
    - b) Cross-connect termination devices.
- B. Related Sections
  - 1. All Division 27 Sections
  - 2. Common Work Results
    - a) Division 27 – “Operation and Maintenance of Structured Cabling and Enclosures”
    - b) Division 27 – “Basic Materials and Methods”
    - c) Division 27 – “Grounding and Bonding for Communications Systems”
    - d) Division 27 - “Pathways for Communications Systems”.
    - e) Division 27 – “Firestopping for Communications Systems”
    - f) Division 27 – “Identification for Communications Systems”
    - g) Division 27 – “Verification Testing of Structured Cabling”
  - 3. Interrelated Sections
    - a) Division 27 – “Communications Wall Linings”
    - b) Division 27 – “Communications Cabinet Rack Frames and Enclosures”
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### **1.3 REFERENCES**

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-568-C.2 – Balanced Twisted Pair Telecommunications Cabling and Components Standard
- D. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- E. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- F. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. The system shall be a multi-pair UTP copper backbone cabling system
    - 1. Provide, test, and label all cables and terminations devices as described below and as shown on the plans.
    - 2. The system shall be an ANSI/TIA/EIA 568-B compliant Unshielded Twisted Pair (UTP) backbone cabling system.
    - 3. The Backbone voice cabling system shall be a Category 3 or greater compliant system.
    - 4. See related Drawings for specific Project requirements.
  - B. The system shall consist of total connectivity for a complete and permanent installed communications link(s).
    - 1. Refer to Backbone Diagram for types, quantities of cables.
    - 2. Refer to detail drawings for terminations standards and positioning of termination devices.
    - 3. Refer to floor plans for termination locations.
    - 4. All cables shall be continuous without splices and shall be of proper construction for the designated use.
5. All system cables shall be UL/NEC rated for the location, manner and site conditions in which the cables are installed. This includes, but is not limited to:
- a) Use of the cable rated for the application

- b) Not exceeding fill capacities of raceways
- c) All cable used shall be in compliance with Local, State, and Federal laws (at minimum the NFPA published “National Electric Code”) as to acceptability for placement in the designed pathway. This includes, but is not limited to, cable fill capacities of raceways and plenum vs. non-plenum construction. The Contractor shall provide and install the appropriate cable for the appropriate conditions.

## 1.5 SUBMITTALS

### A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
2. Samples shall be submitted with or immediately following submission of Product Data submittals.

### B. Items to be submitted for approval prior to commencement of work:

#### 1. Product Data

- a) Manufacture datasheets for all cable
- b) Manufacture datasheets for all connectors
  - 1) Data sheets shall include
    - i) Manufacturer name
    - ii) Manufacturer model number (as it appears on manufacturer’s product data sheet)
    - iii) Manufacturer product description
    - iv) Paragraph number of this section where the product is specified.
    - v) Picture or Drawing of item

### C. Shop Drawings required if different than Bid Documents.

#### 1. Plan Drawing(s)

- a) Depicting the location of all drops and major equipment locations at the project site, coordinate with work of related sections.

#### 2. System Riser Diagram(s).

- a) Depicting the interconnecting cabling between system equipment located at different locations at the project site.

#### 3. Telecommunications Backboard Elevations

- a) Location of products shall be coordinated with work of other sections.
- b) Layout of termination devices.

#### 4. System block wiring diagram, detailed.

### D. Quality Assurance / Control Submittals

1. RCDD Certification for the staff member responsible for this project.
2. Resume of the last 10 projects of the RCDD responsible for this project
3. BICSI Technician’s certificate for each lead Technician(s) on the project

E. Closeout Submittal

1. Backbone diagram indicating all backbone cables and the connectivity provided; i.e. show cable types and the to-and-from locations for each.
2. Equipment Room/Telecommunications Room rack/cabinet layouts (to scale) showing rack space used by each installed component.
3. A diagram of the labeling scheme used on the Project.
4. Cable manufacturer's certification of quality and performance.

**PART 2 PRODUCTS**

2.1 PRODUCT STANDARDS

A. General

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not enumerated will be evaluated as a performance specification based on the information provided on the Drawings.

2.2 CABLES

A. General

1. All cables on this Project shall be color-coded. \*\*\*See Detail drawings for color code.
2. CMP (OFNP) and CMR (OFNR) references below are as required by the NEC published by the National Fire Protection Association.
  - a) Cables not specifically identified otherwise, shall be provided with CMP classification.
  - b) Exceptions:
    - 1) Requirements for Outside Plant Rated cables.
    - 2) Cables run in continuous conduit.
    - 3) Proper cable classification is ultimately determined by building construction; reductions in classification for cables, not clarified or altered by addendum to the specifications, will require a deduct in price through a change order.
3. All references below for pathways, conduits, etc. are as defined by Section 17100 "Telecommunications Pathways".

B. Twisted Pair Cables

1. Electrical Requirements:
  - a) All Twisted Pair cable is required to have the appropriate Category classification as defined by EIA/TIA/ANSI 568B. The compliance to these

electrical characteristics must be third party verified by the manufacturer. Part 1 of this specification Section will define the appropriate Category for each cable.

- b) Recognized Categories:
  - 1) Category 1-2, Category 3, Category 5e, Category 6, Category 6A
  - 2) All requirements and testing parameters as set forth by EIA/TIA 568B.
- 2. Construction
  - a) All Twisted pair cable will be properly constructed for the environmental conditions and to meet all applicable codes.
  - b) The following basic construction types are recognized for this Project:
    - 1) Multi-pair Distribution Cables - Category 3 or greater
      - i) Fully ANSI/EIA/TIA 568B.1 Category 3 compliant
      - ii) Cable shall have 2 individual insulated 24 AWG solid copper conductors formed into a twisted pair.
      - iii) Cable must be constructed of one or more 25 pair bundles of individually insulated Unshielded Twisted Pairs (UTP)
      - iv) Cables will range from 25 pair to 200 pair in 25 pair increments.
      - v) The cable construction must be available in plenum (CMP) and non-plenum riser (CMR) rated constructions.
      - vi) This cable construction is used in indoor pathways primarily as backbone cable.
      - vii) This cable construction will never be used in an outdoor or harsh environment. See Multi-pair Outdoor cables.
      - viii) Standard of quality shall be as manufactured by General Cable 2131377 100pr CMP; CMR 100pr equivalent General Cable 2133144 (Confirm Color)  
(A) Additional approved manufacturers
    - 2) Large pair count Distribution Cables
      - i) Each pair shall have 2 individual insulated 22 AWG solid copper conductors formed into a twisted pair.
      - ii) Cable must be constructed of 25 pair bundles of individually insulated Unshielded Twisted Pairs (UTP)
      - iii) Cables will range from 25 pair to 1800 pair in 25 pair increments.
      - iv) The cable construction shall be suitable for building risers.
      - v) This cable construction is used in indoor pathways primarily as backbone cable.
      - vi) This cable construction will never be used in an outdoor or harsh environment. See Multi-pair Outdoor cables.
      - vii) Standard of quality shall be as manufactured by General Cable 6987275 (600pr.) and 6937817 (900pr.).  
(A) Additional approved manufacturers: Essex Wire and Cable

## 2.3 TERMINATION HARDWARE

### A. General

1. Suggested layout of termination hardware is indicated on the Drawings. Coordinate layout of termination hardware with the Owner's Representative or Consultant/Architect/Engineer before installation.
  2. Provide one single manufacturer for all twisted-pair termination hardware used together in a permanent link or whenever a Category Certification is required.
  3. The manufacturer of the cable and the manufacturer of the connectivity products shall have a partnership agreement established in order to provide the required warranty. See Warranty requirements above and in related Section 27 00 10.00.
  4. All devices shall be UL listed as required by the NEC published by the National Fire Protection Association.
  5. All RJ-45 twisted pair termination devices are required to have the appropriate Category classification as defined by EIA/TIA/ANSI 568B. The compliance to these electrical characteristics must be third party verified by the manufacturer. Part 1 of this specification Section will define the appropriate Category for each cable.
    - a) Recognized Categories:
      - 1) Category 1-2, Category 3, Category 5e, Category 6, Category 6A
      - 2) All requirements and testing parameters as set forth by EIA/TIA 568B.
- B. Wall-mounted Termination
1. The following basic termination devices are available and recognized for this Project.
    - a) 66 style 50 pair base with wall mounted bracket
      - 1) Shall utilize Industry normal footprint
      - 2) Must have labeling areas on front and available label kits
      - 3) 66 style IDC termination system
      - 4) Standard of quality shall be Suttle 66M1-50
- C. Cabinet/Rack Termination
1. UTP Cat 6A Patch Panel 24 port
    - a) Panel shall be black steel with PCB connection between interfaces
    - b) Shall provide 24 ports in 1.75" of rack space (1 RU).
    - c) Must have labeling areas on front and rear
    - d) Fully compliant ANSI/TIA/EIA 568B Category 6A
    - e) RJ45 jack interface on front and 110 style IDC connections on rear
    - f) Mountable in EIA standard 19" rack/cabinet rails.
    - g) Standard of quality shall be Panduit CPPL24WBLY 24-Port Modular Patch Panel with Labels fully loaded with Panduit CJ6X88TGBL Category 6A Jack Modules.

## **PART 3 EXECUTION**

### **3.1 GENERAL**

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all

procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

### 3.2 INSTALLATION

#### A. Coordination

1. Review and coordinate proper pathways prior to installation.

#### B. General

1. Cable routing is to follow building structure lines and should be installed with adequate length to reach to any location in the cabinet/racks plus a 5' service loop at each end.
2. At final termination, excess cable and the service loop shall be looped neatly in cable tray designed for this purpose in the ER/TR and above the ceiling line at an accessible point at the station end.
  - a) Proper strain relief shall be applied to all cables after installation to lessen risk of physical damage and to provide proper aesthetic value.
3. Throughout the entire installation the Contractor must maintain complete protection of all cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades. Cabling shall be bundled, supported, and protected up out of the way of other trades any time it is determined by the Architect/Engineer to be necessary.
4. Separate all cabling by service and type (i.e. voice, data, control, coax) in the Equipment Rooms/Telecommunications Rooms before terminating. Terminate all cabling on specified termination hardware in numerical order and on specified outlets. Do not terminate mixed services on a single patch panel. Neatly dress and securely attach all cabling to the backboard and/or rack.
5. Terminate all cable on both ends using proper tools and manufacturer's instructions.
6. Label all cabling and terminations as indicated.
7. Install all cabling in appropriate raceways. Exposed cables are not to be allowed.
8. Provide sleeves for all penetrations. Patch and firestop around the sleeve and provide the appropriate bushings on each end (split bushings will not be allowed). Firestop the interior of the sleeve after cable is installed.
9. Firestop all wall penetrations to return the wall to its original rating. The Contractor is not responsible for previous penetrations in the firewall if not used for the cabling for this Project. However, if cabling passes through a penetration previously opened it is the responsibility of the cabling vendor to firestop that penetration.
10. Provide waterproof sealant for all penetrations in humidity controlled areas.
11. To avoid Electromagnetic Interference (EMI), all pathways shall provide clearances of at least 1.2m (4ft) from motors or transformers, .3m (1 ft) from

conduit and cables used for electrical power distribution, and 12 cm (5 in) from fluorescent lighting.

12. Install all cabling in conduit or raceway where exposed to public view. Entry/exit from such structures shall be in a uniform and consistent manner and shall not exceed the minimum bend radius of the cable.
13. Route all cabling and pathways parallel or at 90 degree angles to the rafters. Support with the appropriate cable supports supported from the building structure.
14. Where cabling is not supported by cable tray or conduit, provide necessary cable support as specified. Provide nylon cable tie at the support to contain cabling within the support. Do not bundle cable between supports. Provide cable support as specified at intervals not to exceed 5 feet. Do not secure cabling to the support. Do not use cable supports with round surfaces (i.e. bridal rings).
15. All systems' cable runs are to be continuous without splices. All wiring is to be free from grounds, shorts, opens, and reversals.
16. Provide proper strain relief at all connection points.
17. Test and document all cables as specified.

C. Backbone cabling:

1. Provide service loop as specified or a minimum of 5 feet at each end and 10 feet at each junction point.
2. Do not violate the minimum bend radius specified by the manufacturer of the cable.
3. Provide buffer tubing on all fiber strands from the connector to the cable break-out (minimum 6 inch pigtails) and secure to the cable jacket for all fiber optic cables that do not have a cladding.
4. Route intra-building backbone cabling through primary pathways between Equipment Rooms/Telecommunications Rooms.

### 3.3 TESTING

A. Testing:

1. Backbone Copper Cabling:

- a) See: "Verification Testing of Structured Cabling"

B. NOTE: The Owner reserves the right to have a representative present during any or all testing procedures. Verification testing of copper and fiber will be performed at or near Project completion by the Consultant for quality assurance.

C. Upon verification testing, if the Consultant finds the test results do not match the Contractor's results, the Consultant or a third party may at the Owner's request retest all of the cabling and submit those results to the Owner and deduct the verification testing costs from the Contractor's Contract amount.

**END OF SECTION 27 13 13**

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## COMMUNICATIONS FIBER OPTIC BACKBONE CABLING

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Sections for additive information where applicable.

#### 1.2 SUMMARY

- 1. Supply and installation of a complete and working Fiber Optic Backbone Cabling Systems for
  - a) Multi-Purpose Fiber Optic Backbone
    - 1) Including Data connectivity provisions for Data Network and Other Systems (i.e. Video Surveillance, Access Control, Control Data, Intrusion Detection, etc.).
- 2. System includes but is not limited to:
  - a) Backbone cabling.
  - b) Connectors
  - c) Patch panels
- B. Related Sections
  - 1. All Division 27 Sections
  - 2. Common Work Results
    - a) Division 27 – “Operation and Maintenance of Structured Cabling and Enclosures”
    - b) Division 27 – “Basic Materials and Methods”
    - c) Division 27 – “Grounding and Bonding for Communications Systems”
    - d) Division 27 - “Pathways for Communications Systems”.
    - e) Division 27 – “Firestopping for Communications Systems”
    - f) Division 27 – “Identification for Communications Systems”
    - g) Division 27 – “Commissioning of Structured Cabling”
  - 3. Interrelated Sections
    - a) Division 27 – “Communications Wall Linings”
    - b) Division 27 – “Communications Cabinets, Racks, Frames and Enclosures”
- C. Related Drawings
  - 1. Technology (T-Series) Drawings

#### 1.3 REFERENCES

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard
- D. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- E. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- F. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

#### 1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. The system shall be a multi-strand Fiber Optic backbone cabling system
  - 1. Provide, test, and label all cables and terminations devices as described below and as shown on the plans.
  - 2. The system shall be an ANSI/TIA/EIA 568-B compliant Fiber Optic backbone cabling system.
  - 3. See related Drawings for specific Project requirements.
  - 4. The system shall consist of total connectivity for a complete and permanent installed communications link.
  - 5. Refer to Backbone Diagram for types, quantities of cables.
  - 6. Refer to detail drawings for terminations standards and positioning of termination devices.
  - 7. Refer to floor plans for termination locations.
  - 8. All cables shall be continuous without splices and shall be of proper construction for the designated use.
  - 9. All system cables shall be UL/NEC rated for the location, manner and site conditions in which the cables are installed. This includes, but is not limited to:
    - a) Use of the cable rated for the application
    - b) Not exceeding fill capacities of raceways
    - c) All cable used shall be in compliance with Local, State, and Federal laws (at minimum the NFPA published “National Electric Code”) as to acceptability for placement in the designed pathway. This includes, but is not limited to, cable fill capacities of raceways and plenum vs. non-plenum construction. The Contractor shall provide and install the appropriate cable for the appropriate conditions.
    - d) Fiber Optic Backbone (Multi-purpose)

#### 1.5 SUBMITTALS

- A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
  2. Samples shall be submitted with or immediately following submission of Product Data submittals.
- B. Items to be submitted for approval prior to commencement of work:
1. Product Data
    - a) Manufacture datasheets for all cable
    - b) Manufacture datasheets for all connectors
      - 1) Data sheets shall include
        - i) Manufacturer name
        - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
        - iii) Manufacturer product description
        - iv) Paragraph number of this section where the product is specified.
        - v) Picture or Drawing of item
- C. Quality Assurance / Control Submittals
1. RCDD Certification for the staff member responsible for this project.
  2. Resume of the last 10 projects of the RCDD responsible for this project
  3. BICSI Technician's certificate for each lead Technician(s) on the project
- D. Closeout Submittal
1. Backbone diagram indicating all backbone cables and the connectivity provided; i.e. show cable types and the to-and-from locations for each.
  2. Equipment Room/Telecommunications Room rack/cabinet layouts (to scale) showing rack space used by each installed component.
  3. A diagram of the labeling scheme used on the Project.
  4. Cable manufacturer's certification of quality and performance.
  5. Extended Warranty Certificate.
- 1.6 WARRANTY
- A. Additional requirements: All cabling and connectivity products manufacturers, including patch cords, shall have in place an agreement recognizing each other for complete execution of warranty as specified. All performance and applications warranties shall be channel rated.
1. The cable manufacturer and the connectivity products manufacturer shall have a partnership agreement established in order to provide the required warranty.
  2. Required warranty:
    - a) The ANSI/TIA/EIA 568-B Proposed compliant cable system shall include as a minimum a 15 year extended product warranty and performance/applications assurance program.

## **PART 2 PRODUCTS**

### **2.1 PRODUCT STANDARDS**

#### **A. General**

1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
3. Products required by the Drawings but not enumerated will be evaluated as a performance specification based on the information provided on the Drawings.

### **2.2 CABLES**

#### **A. General**

1. All cables on this Project shall be color-coded. \*\*\*See Detail drawings for color code.
2. OFNP and OFNR references below are as required by the NEC published by the National Fire Protection Association.
  - a) Cables not specifically identified otherwise, shall be provided with OFNP classification.
  - b) Exceptions:
    - 1) Requirements for Outside Plant Rated cables.
    - 2) Cables run in continuous conduit.
    - 3) Proper cable classification is ultimately determined by building construction; reductions in classification for cables, not clarified or altered by addendum to the specifications, will require a deduct in price through a change order.
3. All references below for pathways, conduits, etc. are as defined by Section 27 05 28 "Pathways for Communications Systems".

#### **B. Fiber Optic Cables:**

##### **1. General**

- a) Where Multimode and Singlemode fiber optic cable requirements share the same start point, the same end point, and the same pathway, hybrid cables may be used to combine the Multimode and Singlemode strands under a common jacket.
- b) All indoor fiber optic cable shall be of interlocking armored construction.
  - 1) Any fiber optic cable not of interlocking armored construction will be installed in a properly rated (plenum) inner-duct as specified in related Section 27 05 28.00 "Telecommunications Pathways".

##### **2. Optical Requirements:**

- a) All Multimode OM4 Fiber optic cable is required to have the following optical characteristics:
    - 1) Optimized multi-mode fiber cable shall be 50/125 micron diameter with dual window of 850/1300 nm with industry standard color coding. Optical characteristics will include minimum Modal Bandwidth of 4700 MHz/km @ 850nm and 500 MHz/km @ 1300nm allowing guaranteed GigaBit Ethernet distances of 1000m @ the SX wavelength and 550m @ the LX wavelength. With 10 GigaBit Ethernet distances of 550m @ the 10 GigaBit SR wavelength.
      - i) Maximum attenuation – (dB/km) 2.3 @ 850 nm and 0.6 @ 1300 nm.
  - b) All Multimode non-OM4 fiber optic cable is required to have the following optical characteristics:
    - 1) Optimized multi-mode fiber cable shall be 62.5/125 micron diameter with dual window of 850/1300 nm with industry standard color coding. Optical characteristics will include minimum Modal Bandwidth of 200 MHz/km @ 850nm and 500 MHz/km @ 1300nm allowing guaranteed GigaBit Ethernet distances of 300m @ the SX wavelength and 550m @ the LX wavelength.
      - i) Maximum attenuation – (dB/km) 3.75 @ 850 nm and 1.5 @ 1300 nm.
      - ii) Typical attenuation – (dB/km) 3.0 @ 850 nm and 1.0 @ 1300 nm.
      - iii) Minimum bandwidth (MHz/km) 200/1000.
  - c) All Singlemode fiber optic cable is required to have the following optical characteristics:
    - 1) Singlemode fiber cable shall be 8.3/125 micron diameter with dual window of 1310/1550 nm with industry standard color coding. Cable shall meet EIA/TIA 492BAAA (detailed specification for class Ia dispersion un-shifted single-mode optical waveguide/fibers cable used in communications systems).
      - i) Maximum attenuation – (dB/km) .7 @ 1310 nm and .7 @ 1550 nm.
      - ii) Typical attenuation – (dB/km) 3.0 @ 850 nm and 1.0 @ 1300 nm.
3. Construction
- a) Cable shall be of all-dielectric construction unless specifically noted otherwise.
  - b) All fiber optic cable will be properly constructed for the environmental conditions and to meet all applicable codes.
  - c) The following basic construction types are recognized on this Project:
    - 1) Tight buffer armored premise distribution cable
      - i) Plenum (OFNP) rated construction unless otherwise specifically noted.
      - ii) Used in indoor pathways primarily as backbone cable.
      - iii) Fiber counts can range from 4 to 72 strands
      - iv) Hybrid SM/MM strand mix is acceptable.
      - v) This cable construction will never be used in an outdoor or harsh environment.
      - vi) Standard of quality shall be as manufactured by General Cable CG024IPNU-ILP(A) (MM 24 STRAND) AP006IPNU-ILPA (SM 6 STRAND) (Confirm Color and Strand Count )

- vii) Additional approved manufacturers:
  - (A) Commscope P-12-DS-6F-00MM and P-6-DS-8F-00 SM
  - (B) Corning 12K81-31141-00 MM and 6R81-31131-00 SM

## 2.3 TERMINATION HARDWARE

### A. General

1. Suggested layout of termination hardware is indicated on the Drawings. Coordinate layout of termination hardware with the Owner's Representative or Consultant/Architect/Engineer before installation.
2. The manufacturer of the cable and the manufacturer of the connectivity products shall have a partnership agreement established in order to provide the required warranty. See Warranty requirements above and in related Section 27 00 01.00.
3. All devices shall be UL listed as required by the NEC published by the National Fire Protection Association.

### B. Equipment/Telecommunications Room Cabinet/Rack

1. The following basic termination devices are available and recognized for this Project.
  - a) Fiber Optic Patch Panel 24 port
    - 1) Panel shall be black steel with smoked plexiglass door
    - 2) Rear tray capacity for optional splice trays
    - 3) Slack management spools included
    - 4) Drawers slide out for easy front access
    - 5) Accepts standard 6-pack assemblies; 4 units (FAP or FMP)
    - 6) Mountable in 1 rack space (1.75") EIA standard 19" rack/cabinet rails.
    - 7) Must use F/O Coupler Packs; see below
    - 8) Standard of quality shall be Panduit FMD1
      - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics
  - b) Fiber Optic Patch Panel 48 port
    - 1) Panel shall be black steel with smoked plexiglass door
    - 2) Rear tray capacity for optional splice trays
    - 3) Slack management spools included
    - 4) Drawers slide out for easy front access
    - 5) Accepts standard 6-pack assemblies; 8 units (FAP or FMP)
    - 6) Mountable in 2 rack spaces (3.50") EIA standard 19" rack/cabinet rails.
    - 7) Must use F/O Coupler Packs; see below
    - 8) Standard of quality shall be Panduit FMD2
      - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics
  - c) Fiber Optic Coupler Packs – Multimode OM4
    - 1) Panel shall be black steel individual couplers installed
    - 2) Mounts in 24 or 48 port Fiber Optic patch panel
    - 3) 6 duplex LC adapters with phosphor bronze sleeves (MM)
    - 4) Color code MM couplers Beige
    - 5) Standard of quality shall be Panduit FAP6WAQDLCZ

- i) Additional approved manufacturers: Hubbell, Leviton, Ortronics
- d) Fiber Optic Coupler Packs – Multimode non-OM4
  - 1) Panel shall be black steel individual couplers installed
  - 2) Mounts in 24 or 48 port Fiber Optic patch panel
  - 3) 6 duplex ST adapters with phosphor bronze sleeves (MM)
  - 4) Color code MM couplers Beige
  - 5) Standard of quality shall be Panduit FAP6WST
    - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics
- e) Fiber Optic Coupler Packs - Singlemode
  - 1) Panel shall be black steel individual couplers installed
  - 2) Mounts in 24 or 48 port Fiber Optic patch panel
  - 3) 6 simplex SC adapters with ceramic sleeves (SM)
  - 4) Color code SM couplers Blue
  - 5) Standard of quality shall be Panduit FAP6WBUSCZ
    - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics

#### C. Wall-mounted Termination

1. The following basic termination devices are available and recognized for this Project.
  - a) Wall Mounted Fiber Optic Patch Panel 24 port
    - 1) Panel shall be black steel with dual doors and locks
    - 2) Tray capacity for optional splice trays
    - 3) Slack management spools included
    - 4) Accepts standard 6-pack assemblies; 4 units (FAP or FMP)
    - 5) Wall Mountable; 13" x 16" x 5"
    - 6) Must use F/O Coupler Packs; see below
    - 7) Standard of quality shall be Panduit FWME4
      - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics
  - b) Fiber Optic Coupler Packs - Singlemode
    - 1) Panel shall be black steel individual couplers installed
    - 2) Mounts in 24 or 48 port Fiber Optic patch panel
    - 3) 6 simplex SC adapters with ceramic sleeves (SM)
    - 4) Color code SM couplers Blue
    - 5) Standard of quality shall be Panduit FAP6WBUSCZ
      - i) Additional approved manufacturers: Hubbell, Leviton, Ortronics

#### D. Discreet Cable Connectors

1. The following basic termination devices are available and recognized on this Project:
  - a) LC Connector Multi-Mode OM4
    - 1) Standard of quality shall be Belden FT4LC2MMFS01
      - i) Additional approved manufacturers: 3M, Leviton, Ortronics, or Hubbell
      - ii) Each connector will use a U/V or adhesive/epoxy to firmly adhere the glass strand to the connector or splice on connection.
  - b) ST Connector Multi-mode non-OM4

- 1) Each connector will use a U/V or adhesive/epoxy to firmly adhere the glass strand to the connector.
- 2) The connector ferrule shall be ceramic.
- 3) The connector must provide .1 dB typical attenuation or less
- 4) Standard of quality shall be Panduit FSTMABL
  - i) Additional approved manufacturers: 3M, Leviton, Ortronics, or Hubbell
- c) SC Connector Single-mode
  - 1) Each connector will use a U/V or adhesive/epoxy to firmly adhere the glass strand to the connector.
  - 2) The connector ferrule shall be ceramic.
  - 3) The connector must provide .3 dB typical attenuation or less
  - 4) Standard of quality shall be Panduit FSCSBU
    - i) Additional approved manufacturers: 3M, Leviton, Ortronics, or Hubbell
- d) Fiber Optic Break-out (fan-out)/(furation) kit.
  - 1) Shall be used for all fiber optic cable terminations
  - 2) Shall include buffer tubing and heat shrink tubing for each strand to have a 18" length from break-out.
  - 3) Standard of quality shall be Corning cable Systems FAN-BT25-xx (Indoor) or FAN-OD25-xx (Outdoor)
    - i) Additional approved manufacturer(s): Hubbell, Leviton, Ortronics Panduit,

### **PART 3 EXECUTION**

#### **3.1 GENERAL REQUIREMENTS**

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

#### **3.2 INSTALLATION PRACTICES**

- A. Standards: The minimum criteria for proper installation can be found in the TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL published by the Building Industry Consulting Services International. The vendor must refer to this publication for cable installation practices. This Specification may take exception to optional statements within this manual. Treat any conflict per this Specification under discrepancies or Conflicts.
- B. General Requirements:
  1. The Contractor shall verify any pathway being provided by others prior to installation.
  2. Cable routing is to follow building structure lines and should be installed with adequate length to reach to any location in the cabinet/racks plus a 5' service loop at each end.

3. At final termination, excess cable and the service loop shall be looped neatly in cable tray designed for this purpose in the ER/TR and above the ceiling line at an accessible point at the station end.
  - a) Proper strain relief shall be applied to all cables after installation to lessen risk of physical damage and to provide proper aesthetic value.
4. Throughout the entire installation the Contractor must maintain complete protection of all cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades. Cabling shall be bundled, supported, and protected up out of the way of other trades any time it is determined by the Architect/Engineer to be necessary.
5. Separate all cabling by service and type (i.e. voice, data, control, coax) in the Equipment Rooms/Telecommunications Rooms before terminating. Terminate all cabling on specified termination hardware in numerical order and on specified outlets. Do not terminate mixed services on a single patch panel. Neatly dress and securely attach all cabling to the backboard and/or rack.
6. Terminate all cable on both ends using proper tools and manufacturer's instructions.
7. Label all cabling and terminations as indicated.
8. Install all cabling in appropriate raceways. Exposed cables are not to be allowed.
9. Provide sleeves for all penetrations. Patch and firestop around the sleeve and provide the appropriate bushings on each end (split bushings will not be allowed). Firestop the interior of the sleeve after cable is installed.
10. Firestop all firewall penetrations to return the wall to its original rating. Outlet boxes installed in firewalls must be similarly firestopped. The Contractor is not responsible for previous penetrations in the firewall if not used for the cabling for this Project. However, if cabling passes through a penetration previously opened it is the responsibility of the cabling vendor to firestop that penetration.
11. Provide waterproof sealant for all penetrations in humidity controlled areas.
12. To avoid Electromagnetic Interference (EMI), all pathways shall provide clearances of at least 1.2m (4ft) from motors or transformers, .3m (1 ft) from conduit and cables used for electrical power distribution, and 12 cm (5 in) from fluorescent lighting.
13. Install all cabling in conduit or raceway where exposed to public view. Entry/exit from such structures shall be in a uniform and consistent manner and shall not exceed the minimum bend radius of the cable.
14. Route all cabling and pathways parallel or at 90 degree angles to the rafters. Support with the appropriate cable supports supported from the building structure.
15. Where cabling is not supported by cable tray or conduit, provide necessary cable support as specified. Provide nylon cable tie at the support to contain cabling within the support. Do not bundle cable between supports. Provide cable support as specified at intervals not to exceed 5 feet. Do not secure cabling to the support. Do not use cable supports with round surfaces (i.e. bridal rings).

16. All systems' cable runs are to be continuous without splices. All wiring is to be free from grounds, shorts, opens, and reversals.
  17. All guidelines of the American Disabilities Act (ADA) shall be followed.
  18. Provide proper strain relief at all connection points.
  19. Form wires and cables routed in racks/cabinets into harnesses. Tie and support for proper strain relief.
  20. Install patch cables in a neat and orderly fashion.
  21. Test and document all cables as specified.
- C. Backbone cabling:
1. Provide service loop as specified or a minimum of 5 feet at each end and 10 feet at each junction point.
  2. Do not violate the minimum bend radius specified by the manufacturer of the cable.
  3. Provide buffer tubing on all fiber strands from the connector to the cable break-out (minimum 6 inch pigtails) and secure to the cable jacket for all fiber optic cables that do not have a cladding.
  4. Route intra-building backbone cabling through primary pathways between Equipment Rooms/Telecommunications Rooms.

### 3.3 TESTING

- A. All cables shall be fully tested and verified compliant with these specifications.
1. See: "Verification Testing of Structured Cabling" for Fiber Optic Backbone performance testing parameters and procedures.
- B. The Owner reserves the right to have a representative present during any or all testing procedures. Owner shall be notified of testing minimally 5 working days before testing. Verification testing of copper and fiber will be performed at or near Project completion by the Consultant for quality assurance.
- C. Upon verification testing, if the Consultant finds the test results do not match the Contractor's results, the Consultant or a third party may at the Owner's request retest all of the cabling and submit those results to the Owner and deduct the verification testing costs from the Contractor's Contract amount.

**END OF SECTION 27 13 23**

## COMMUNICATIONS COPPER HORIZONTAL CABLING

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Supply and installation of a complete and working Horizontal Cabling Systems for
    - a) Voice / Telephone
    - b) Data / Network
      - 1) Including Data provisions for Other Systems (i.e. Video Surveillance, Access Control, Control Data, Intrusion Detection, etc.).
  - 2. System includes but is not limited to:
    - a) Horizontal cabling.
    - b) Station outlets including frames, connector modules, and cover plates.
    - c) Patch panels
- B. Related Sections
  - 1. All Division 27 Sections
  - 2. Common Work Results
    - a) Division 27 – “Operation and Maintenance of Structured Cabling and Enclosures”
    - b) Division 27 – “Basic Materials and Methods”
    - c) Division 27 – “Grounding and Bonding for Communications Systems”
    - d) Division 27 - “Pathways for Communications Systems”.
    - e) Division 27 – “Firestopping for Communications Systems”
    - f) Division 27 – “Identification for Communications Systems”
    - g) Division 27 – “Commissioning of Structured Cabling”
  - 3. Interrelated Sections
    - a) Division 27 – “Communications Cabinets, Racks, Frames and Enclosures”
    - b) Division 27 – “Communications Cable Management and Ladder Rack”

#### C. Related Drawings

- 1. Technology (T-Series) Drawings

### 1.3 REFERENCES

- A. ANSI/TIA/EIA-568-C.0 – Generic Telecommunications Cabling for Customer Premisers.
- B. ANSI/TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard
- C. ANSI/TIA/EIA-568-C.2 – Balanced Twisted Pair Telecommunications Cabling and Components Standard
- D. ANSI/TIA/EIA-568-C.4 – Standard on Coaxial Cabling Components
- E. ANSI/TIA/EIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces.
- F. ANSI/TIA/EIA-606-A – The Administrative Standard for the Telecommunications Infrastructure of Commercial Building.
- G. “TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL” published by the Building Industry Consulting Services International (BISCI).

### 1.4 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

- A. The system shall be a 4 pair UTP copper Horizontal cabling system.
  - 1. Provide, test, and label all cables and terminations devices as described below and as shown on the plans.
  - 2. The system shall be an ANSI/TIA/EIA 568-B Category 6A compliant Unshielded Twisted Pair (UTP) horizontal cabling system.
  - 3. The Horizontal voice cabling systems shall be a Category 6A compliant system.
  - 4. The Horizontal data cabling system shall be a Category 6A compliant system.
  - 5. System shall meet or exceed the requirements for the PanGen System Warranty 25 year warranty and shall include the 25 year PanGen System Warranty. Contractor shall provide PanGen System Warranty documentation at project close out. **Or**,cabling manufacturer and/or contractor shall provide a total system warranty equal to or better than the PanGen System Warranty 25 year warranty. System Warranty documentation shall be provided to Owner Telecommunications department at project close out.
  - 6. See related Drawings for specific Project requirements.
  - 7. The system shall consist of total connectivity for a complete and permanent installed communications link.
  - 8. Refer to detail drawings for terminations standards and positioning of termination devices Provide, test, and label all cables and terminations devices as described below and as shown on the plans.
  - 9. The cable distance between the termination point with a Communications Room(s) and the station outlet(s) shall be no greater then 90 meters (295 ft).
  - 10. The total channel distance shall not exceed 100 meters (328 feet) distance between equipment in the Communications room and station equipment, including all patch cables and station attachment cables

11. All system cables shall be continuous between points of termination, without splices.
12. All system cables shall be UL/NEC rated for the location, manner and site conditions in which the cables are installed. This includes, but is not limited to:
  - a) Use of the cable rated for the application
  - b) Not exceeding fill capacities of raceways
  - c) All cable used shall be in compliance with Local, State, and Federal laws (at minimum the NFPA published "National Electric Code") as to acceptability for placement in the designed pathway. This includes, but is not limited to, cable fill capacities of raceways and plenum vs. non-plenum construction. **ONLY Plenum station cable shall be installed on the Indiana State University campus.** The Contractor shall provide and install the appropriate cable for the appropriate conditions.

## 1.5 SUBMITTALS

### A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
2. Samples shall be submitted with or immediately following submission of Product Data submittals.

### B. Items to be submitted for approval prior to commencement of work:

#### 1. Product Data

- a) Manufacture datasheets for all cable
- b) Manufacture datasheets for all connectors
  - 1) Data sheets shall include
    - i) Manufacturer name
    - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
    - iii) Manufacturer product description
    - iv) Paragraph number of this section where the product is specified.
    - v) Picture or Drawing of item

### C. Quality Assurance / Control Submittals

1. RCDD Certification for the staff member responsible for this project.
2. Resume of the last 10 projects of the RCDD responsible for this project
3. BICSI Technician's certificate for each lead Technician(s) on the project

### D. Closeout Submittal

1. Communication Room Rack Layouts, drawing to scaled, depicting devices and rack space occupied by each installed component.
2. A diagram of the labeling scheme used on the Project.

3. Additional closeout documentation as required in Division 1 and Division 27 “General Requirements for Communications”.
4. Contractor shall provide PanGen System Warranty documentation at project close out. **Or**, cabling manufacturer and/or contractor shall provide a total system warranty equal to or better than the PanGen System Warranty 25 year warranty.

#### 1.6 WARRANTY

- A. Additional requirements: All cabling and connectivity products manufacturers, including patch cords, shall have in place an agreement recognizing each other for complete execution of warranty as specified. All performance and applications warranties shall be channel rated.
  1. The cable manufacturer and the connectivity products manufacturer shall have a partnership agreement established in order to provide the required warranty.
  2. Required warranty:
    - a) The ANSI/TIA/EIA 568-B Proposed Category 6A compliant cable system shall include as a minimum a 25 year PanGen System Warranty. **Or**, cabling manufacturer and/or contractor shall provide a total system warranty equal to or better than the PanGen System Warranty 25 year warranty.

### PART 2 PRODUCTS

#### 2.1 PRODUCT STANDARDS

- A. General
  1. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
  2. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
  3. Products required by the Drawings but not enumerated will be evaluated as a performance specification based on the information provided on the Drawings.

#### 2.2 CABLES

- A. General
  1. All cables on this Project shall be color-coded. \*\*\*See Detail drawings for color code.
  2. CMP (OFNP) and CMR (OFNR) references below are as required by the NEC published by the National Fire Protection Association.
    - a) Cables not specifically identified otherwise, shall be provided with CMP classification.
    - b) Exceptions:
      - 1) Proper cable classification is ultimately determined by building construction; reductions in classification for cables, not clarified or

altered by addendum to the specifications, shall require a contract cost deduction through a change order.

B. Twisted Pair Cables

1. Electrical Requirements:

- a) All Twisted Pair cable is required to have the appropriate Category classification as defined by EIA/TIA/ANSI 568C. The compliance to these electrical characteristics must be third party verified by the manufacturer. Part 1 of this specification Section will define the appropriate Category for each cable.
- b) Recognized Categories:
  - 1) Category 1-2, Category 3, Category 5e, Category 6, Category 6A
  - 2) All requirements and testing parameters as set forth by EIA/TIA 568C.

2. Construction

- a) All Twisted pair cable will be properly constructed for the environmental conditions and to meet all applicable codes.
- b) The following basic construction types are recognized for this Project:
  - 1) Premise Distribution 4 pair Cables - Category 6A
    - i) Fully ANSI/EI/TIA 568C.1 Category 6A compliant
    - ii) Cable shall have 2 individual insulated 24 AWG solid copper conductors formed into a twisted pair.
    - iii) Cable must be constructed of four individually insulated Unshielded Twisted Pairs (UTP)
    - iv) The cable construction must be available in plenum (CMP) and non-plenum riser (CMR) rated constructions.
    - v) This cable construction is used in indoor pathways primarily as horizontal cabling but may also be used as backbone cable.
    - vi) Standard of quality shall be as manufactured by Panduit Cable PUP6AM04BU-UG .
      - (A) Additional approved manufacturer(s):
      - (B) General Cable 7132849
      - (C) CommScope 2091B BLU C6A 4/23 U/UTP W1000 | 760107201
      - (D) Belden 10GXW13
      - (E) Mohawk M59146

## 2.3 TERMINATION HARDWARE

A. General

- 1. Suggested layout of termination hardware is indicated on the Drawings. Contractor shall coordinate layout of termination hardware with the Owner's Representative before installation.
- 2. Provide one single manufacturer for all twisted-pair termination hardware used together in a permanent link or whenever a Category Certification is required.

3. Termination devices on this Project shall be color-coded. \*\*\*\*\*See Detail Drawings for details.
4. The manufacturer of the cable and the manufacturer of the connectivity products shall have a partnership agreement established in order to provide the required warranty. See Warranty requirements above and in related Section 27 00 01.00. Contractor shall provide Owner warranty documentation at project close out.  
All devices shall be UL listed as required by the NEC published by the National Fire Protection Association.
5. All RJ-45 twisted pair termination devices are required to have the appropriate Category classification as defined by EIA/TIA/ANSI 568B. The compliance to these electrical characteristics must be third party verified by the manufacturer. Part 1 of this specification Section will define the appropriate Category for each cable.
  - a) Recognized Categories:
    - 1) Category 1-2, Category 3, Category 5e, Category 6, Category 6A.
    - 2) All requirements and testing parameters as set forth by the latest update to EIA/TIA 568B.

**B. Station Outlet**

1. The following basic termination devices are available and recognized for this Project.
  - a) Flush Faceplate – Single Gang
    - 1) Sloped faceplate Frame
    - 2) Four position minimum on each faceplate
    - 3) Electrical Ivory color unless otherwise specified
    - 4) May be mounted on an outlet box, bracket, or raceway.
    - 5) Must use module inserts below.
    - 6) Standard of quality shall be Panduit CFPSL4xxY
  - b) Quad Jack Frame
    - 1) Four position minimum on each frame
    - 2) Electrical Ivory color unless otherwise specified
    - 3) May be mounted on an outlet box, bracket, or raceway.
    - 4) Will require a faceplate with standard duplex electrical outlet cut-out
    - 5) Standard of quality shall be Panduit CFG4xx
  - c) Faceplate Blank Insert
    - 1) Provide blanks for all un-used positions in faceplates, surface boxes, or jack frames.
    - 2) Color to match outlet faceplate as described above; Electrical Ivory color unless otherwise specified
    - 3) Standard of quality shall be Panduit CMBxx-X
  - d) Wall-Phone Jack
    - 1) Stainless Steel faceplate with mounting posts for keyhole slot telephone mounting

- 2) May be mounted on an outlet box, bracket, or raceway.
  - 3) Standard of quality shall be Panduit KWP6PY.
- e) Category 6A jack insert RJ-45
  - 1) Fully compliant ANSI/TIA/EIA 568B Category 6A RJ45 modular jack.
  - 2) Color shall be Blue for all locations identified as being voice locations. Color shall be Electrical Ivory for all locations identified as data locations. Coordinate with Owner's Representative or Architect/Engineer.
  - 3) Standard of quality shall be Panduit CJ6X88TGxx
- C. Communications Room Equipment Rack(s)
  - 1. The following basic termination devices are available and recognized for this Project.
    - a) UTP Cat 6A Patch Panel 24 port
      - 1) Panel shall be black steel with PCB connection between interfaces
      - 2) Shall provide 24 ports in 1.75" of rack space (1 RU).
      - 3) Must have labeling areas on front and rear
      - 4) Fully compliant ANSI/TIA/EIA 568B Category 6A
      - 5) RJ45 jack interface on front and 110 style IDC connections on rear
      - 6) Mountable in EIA standard 19" rack/cabinet rails.
      - 7) Standard of quality shall be Panduit CPPL24WBL Y 24-Port Modular Patch Panel with Labels fully loaded with Panduit CJ6X88TG B L Category 6A Jack Modules.
- D. Emergency Wall-Phone
  - 1. Viking E-1600-60A Royal Blue Emergency Wall-Mount Telephone with analog connection. Provide where indicated.

## **PART 3 EXECUTION**

### **3.1 GENERAL**

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

### **3.2 INSTALLATION**

- A. Coordination
  - 1. Review and coordinate proper pathways prior to installation.
- B. General
  - 1. Cable routing shall follow building structure lines and shall be installed with adequate length to reach to any location within the equipment racks with at least 5 feet of service loop at each end.

2. At point of final terminations, excess cable and the service loop shall be stored and dressed neatly.
  - a) At the station end of the cable the service loop shall be stored above the ceiling line at an accessible point and support with an approved device designed for that purpose.
  - b) Within a Communications Room the service loop shall be dressed and stored within the ladder rack.
3. Strain relief techniques shall be applied to all cables to lessen the risk of physical cable damage and to provide proper aesthetic value.
4. Route all cabling and pathways parallel to building surfaces and at 90 degrees angles to the rafters and trusses.
5. Cable runs shall be continuous and without splices.
6. Wiring shall be free from grounds, shorts, opens, and reversals. Strain relief shall be provided at all connection points.

C. Protection

1. Maintain protection of all cabling throughout the entire duration of the project. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades. Cabling shall be bundled, supported, and protected up out of the way of other trades any time it is determined necessary to ensure the safety or personnel and protection of the cable.
2. Do not terminate cables designated for different services onto the same patch panel unless otherwise clearly indicated on the drawings. Coordinate with Owner before any terminations are made.
3. Do not exceed minimum bend radius or pulling tension specifications set forth by the product manufacturer.
4. Cable Separation and Organization
  - a) Horizontal cables of all service types (i.e. Voice, Data, Control, RF, etc....) shall be organized and kept segregated within cable trays, ladder rack, wire management and other pathways to the degree physically possible.
  - b) Cables of different services shall not be intertwined.
  - c) Terminate all cabling on specified termination hardware in numerical order and on specified outlets.

D. Labeling

1. Every cable shall have a label applied to the jacket at each end.
2. Each terminating device and port shall have a unique identifier.
3. Label all cabling and terminations as specified and indicated on related drawings.

E. Use of Raceways

1. Install cabling within conduit and in surface raceway where specified in this or related sections and as indicated on the drawings.

2. Cabling shall be installed in a concealed manner. Cables may be visible only in the following areas;
    - a) Equipment Rooms
    - b) Telecommunications Rooms
    - c) Building spaces equipped with cable trays, but without finished ceilings to conceal the cables.
  3. Install cabling in Cable Tray / and Ladder rack where specified and/or indicated on the drawings.
  4. Support cables using approved products and methods whenever conduit, surface raceway and cable tray are not specified. Cable supports shall be attached directly to building structure.
- F. Cabling on backboards and in Equipment racks
1. Neatly dress, support, and securely attach all cabling.
- G. Termination
1. Terminate each end of every cable provided.
  2. Terminate each cable from a station outlet in numerical order on adjacent ports on the specified termination hardware within the appropriate Communications Room.
  3. Terminate cables using the tools and connectors specified and as recommended by the cable/connector manufacturer.
- H. Separation from Sources of Interference
1. Route cables at least 1.2m (4 foot) from motors or transformers; 30 cm (1 foot) from conduit and cables used for AC power distribution; 12 cm (5 inches) from fluorescent lighting fixtures.
- I. Cable Supports
1. Where cabling is not supported by cable tray or conduit, provide necessary cable support as specified. Provide nylon cable tie at the support to contain cabling within the support. Do not bundle cable between supports. Provide cable support as specified at intervals not to exceed 5 feet. Do not secure cabling to the support. Do not use cable supports with round surfaces (i.e. bridal rings).
- J. Horizontal cabling
1. The length of patch cords and cross connect jumpers installed in the Telecommunications Room shall be 5 m (15 ft) total or less.
  2. The length of patch cords and cross connect jumpers installed in the Equipment Room shall be 5 m (15 ft) total or less.
  3. Locate telecommunications outlets so that the cable assembly required to reach work area equipment will be no more than 5 m (15 ft) long.

4. Provide service loops on all cables at the station end of 2 feet (coiled above the ceiling and with a minimum of 6 inches at the telecommunications outlet coiled in the box or raceway).
5. Provide service loop at the Equipment Room/Telecommunications Room end of 5 feet coiled above the ceiling or neatly bundled in ladder rack above the cabinet/rack.
6. Install telecommunications outlets securely at work area locations.
7. Any necessary electrical components (e.g., impedance-matching devices) at outlets shall be located outside the faceplate via a standard plug connection.
8. Provide surface raceway on all walls where existing pathway has not been provided and cables cannot be concealed inside the wall cavity. Do not conceal cabling inside of block walls. Install surface raceway “level” straight and securely anchored to walls with screws, bolts, or anchors as appropriate.
9. Provide a 6 inch service loop on each horizontal UTP cable that breaks out from the harness for termination and do not violate the minimum bend radius of the cable.

### 3.3 TESTING

- A. All cables shall be fully tested and verified compliant with these specifications.
  1. See: “Commissioning of Structured Cabling” for UTP Horizontal performance testing parameters and procedures.
- B. The Owner reserves the right to have a representative present during any or all testing procedures. Verification testing of copper and fiber will be performed at or near Project completion by the Consultant for quality assurance.
- C. Upon verification testing, if the Consultant finds the test results do not match the Contractor’s results, the Consultant or a third party may at the Owner’s request retest all of the cabling and submit those results to the Owner and deduct the verification testing costs from the Contractor’s Contract amount.

**END OF SECTION 27 15 13.00**

## COMMUNICATIONS CONNECTING CORDS, DEVICES, AND ADAPTERS

### PART 1 GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
  - 1. Supplementary to Division 1, Refer to Division 27 Section(s) for additive information where applicable.

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Cable Assemblies, Devices, and Adapters for Communications
    - a) Voice / Telephone
    - b) Data / Network
  - 2. General requirements are as follows:
    - a) Provide cable assemblies and devices with electrical/optical properties to match the designed infrastructure.
  - 3. Special requirements are as noted on Drawings.
  - 4. All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.
- B. Products Supplied But Not Installed Under This Section
  - 1. None
- C. Products Installed But Not Supplied Under This Section
  - 1. None
- D. Related Sections
  - 1. All Division 27 Sections
- E. Related Drawings
  - 1. Technology (T-Series) Drawings

#### 1.3 SYSTEM DESCRIPTION

- A. Provide the following cable assemblies (cords), Devices, and adapters: **(only provide if specifically requested by Owner)**
  - 1. Telephone Patch Cables
    - a) Category 6A cables, 3-5 feet in length as required for the Equipment Room/Telecommunications Room end.
    - b) Confirm Color for telephone cables
    - c) Labeled with the same unique identifier at both ends of the assembly.
    - d) Provide a quantity of 1 for each horizontal telephone cable installed.

B. Labels:

1. Provide alphanumeric, clearly typewritten labels at all designated points as follows:
2. See Detail Drawings for graphical representation of labeling scheme.

1.4 SUBMITTALS

A. General

1. Product Data and Shop Drawing submittals for work of this section shall be SUBMITTED TOGETHER, complete, as a single submittal. Product Data and Shop Drawings are not to be submitted separately.
2. Samples shall be submitted with or immediately following submission of Product Data submittals.

B. Items to be submitted for approval prior to commencement of work:

1. Product Data

- a) Manufacture datasheets for all cable assemblies
- b) Manufacture datasheets for all devices
- c) Manufacture datasheets for all adapters
  - 1) Data sheets shall include
    - i) Manufacturer name
    - ii) Manufacturer model number (as it appears on manufacturer's product data sheet)
    - iii) Manufacturer product description
    - iv) Paragraph number of this section where the product is specified.
    - v) Picture or Drawing of item

C. Closeout Submittal

1. Cable color code utilized for patching.
2. Labeling scheme utilized for cable assemblies.

**PART 2 PRODUCTS**

2.1 PRODUCT STANDARDS

A. General

1. As required in Division 27 Section 27 00 01 "General Requirements for Communications"
2. This section is designed to provide the Contractor with a minimum standard of quality and functionality for the products used for telecommunications infrastructure.
3. This standard will be considered in force for the original response as well as for any additions or changes to this Project. Due to this, there may be items listed in the Products section that are not required under the scope of this contract.
4. Products required by the Drawings but not listed in Part 2, will be evaluated as a performance specification based on the information provided on the Drawings.

2.2 CABLES

A. Copper Cable Assemblies (Twisted Pair)

1. Category 6A Copper patch cables

- a) Copper patch cables shall be ANSI/TIA/EIA 568A Proposed Category 6A compliant with eight position RJ45 modular plugs on each end. Use T568A wiring. Apply an identifying label to each end of the cable assembly (same identifier on each end of the cable and a unique identifier for each patch cable on the Project regardless of installed location).
- b) Color Coding:
  - 1) Critical Building Systems Red
  - 2) Voice Over IP Orange
  - 3) Classroom Black
  - 4) Administrative Yellow
  - 5) Cross-Over connections Blue
  - 6) Straight-Through uplinks Green
  - 7) Network Management Purple
  - 8) IP Video White
  - 9) Work Area (Attachment) Gray
- c) UTP Cable Assemblies Category 6A, coordinate with Owner prior to purchasing cables. In most cases data patch cables will be six inch.
  - 1) Standard of quality shall be Panduit
    - i) 6 inch with labels added
    - ii) 3 foot with labels added
    - iii) 5 foot with labels added
    - iv) 7 foot with labels added
    - v) 10 foot with labels added
    - vi) 14 foot with labels added
    - vii) 20 foot with labels added
  - 2) Additional Approved Manufacturers:

**PART 3 EXECUTION**

3.1 GENERAL REQUIREMENTS

- A. This section is designed to provide the vendor with a standard of quality and functionality for the installation of technology systems infrastructure. Not all procedures will be necessary for the installation of this Project. However, this standard will be considered in force for the original response as well as for any additions or changes to this Project.

3.2 INSTALLATION PRACTICES

- A. Standards: The minimum criteria for proper installation can be found in the *TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL* published by the Building Industry Consulting Services International. The vendor must refer to this publication for cable installation practices. This Specification may take exception to

- optional statements within this manual. Treat any conflict per this Specification under discrepancies or Conflicts.
- B. The following items should be considered to be minimum standards for this Project:
    - 1. The vendor is responsible for receiving, handling, storing, and protecting all materials used on this Project until the Project is signed as complete.
  - C. General Requirements:
    - 1. Throughout the entire installation the Contractor must maintain complete protection of all cabling. Cabling shall not be left hanging or coiled where it potentially obstructs the Work of other trades. Cabling shall be bundled, supported, and protected up out of the way of other trades any time it is determined by the Architect/Engineer to be necessary.
- 3.3 LABELING
- A. Provide labeling as specified in Part I.
  - B. Label all items listed in quantities required by the drawings and specifications.
  - C. Apply all labels straight and legible.

**END OF SECTION 27 16 00.00**

## **INSTRUCTIONAL CLASSROOM AUDIO AND VIDEO SYSTEMS**

### **PART 1 GENERAL**

#### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1. Supplementary to Division 1, Refer to Division 27 Section 27 00 10 - "General Requirements for Communications" for additional information and work that is applicable to this section.

#### **1.2 SUMMARY**

- A. Section Includes:

1. Instructional classroom audio/video systems complete and functional as indicated.

- B. Related Sections

1. All Division 27 Sections
2. Common Work Results
  - a) Division 27 – "Operation and Maintenance of Structured Cabling and Enclosures"
  - b) Division 27 – "Basic Materials and Methods"
  - c) Division 27 - "Pathways for Communications Systems".
  - d) Division 27 – "Firestopping for Communications Systems"
  - e) Division 27 – "Identification for Communications Systems"
  - f) Division 27 – "Commissioning of Structured Cabling"

- C. Related Drawings

1. All Technology Drawings (T-series)

#### **1.3 DEFINITIONS**

- A. Devices: As used with this section, devices shall refer to product(s) that are assembled to the front, side, rear, top or bottom of a custom plate/panel. Sample "devices" include, but are not limited to connectors, switches, lamp assemblies, meters, faders, and potentiometers.

- B. Components: As used with this section only, components shall refer to passive and active electronic parts used as part of an assembly that are otherwise considered plates, panels, hardware or devices.

- C. RGB: Red, Green, Blue

- D. RGBS: Red, Green, Blue, Sync

- E. RGBHV: Red, Green, Blue, Horizontal Sync, Vertical Sync

- F. Y-C: Chrominance, Luminance

- G. S-Video: Chrominance, Luminance
- H. DCR = Direct Current Resistance
- I. DVI = Digital Video Interface
- J. HDMI = High Definition Media Interface
- K. SDI = Serial Digital Interface
- L. HDSDI = High Definition Serial Digital Interface

#### 1.4 REFERENCES

- A. National Electric Code
- B. NFPA

#### 1.5 SYSTEM DESCRIPTION / DESCRIPTION OF WORK

##### A. Classroom audio/video systems complete to include:

1. Television displays
2. Ceiling-mounted video projectors
3. Control panels
4. Lecterns
5. Scalers
6. Switchers
7. Cabling system
8. Custom input plates
9. Software complete as indicated
10. Cameras
11. Confidence monitors
12. Touch panels
13. Microphones
14. Speakers

#### 1.6 SUBMITTALS

- A. Only one contractor (the Division 27 Prime Contract holder) shall furnish the submittals for this section. The submittal shall be inclusive of all materials to be furnished under this section.
- B. Provide datasheets of all models of cable and connectors to be supplied.
- C. Assemblies only from pre-approved manufacturers shall be deemed acceptable. Contractor fabricated products shall not be permitted.
- D. All assembly products furnished under this section shall be from a single manufacturer.
- E. Shop Drawings
  1. Scaled engineering level datasheets for each plate/panel assembly.
    - a) Drawing scale shall be 1/2-inch = 1-inch or 1-inch = 1-inch

- b) Paper size: 8-1/2-inches by 11 inches or 11-inches by 17-inches as appropriate for the assembly
- c) Each datasheet shall clearly indicate all of the following:
  - 1) The manufacturer of the assembly.
  - 2) Plate/panel material, finish, and color.
  - 3) Plate/panel dimensions.
  - 4) Mounting hole quantity, sizing and spacing.
    - i) Not required when using “standard” electrical “gang” plate sizes and standard EIA rack mount panels.
  - 5) Properties of all Text nomenclature.
    - i) Font
    - ii) Font Sizes
    - iii) Colors
    - iv) Line widths
  - 6) Properties of all non-text nomenclature
  - 7) Detailed list of devices used within the assembly.
- 2. Schematic diagram of all assemblies
  - a) Wiring for those assemblies that have interconnections between devices and components, and for assemblies that feature consolidated connectivity points (screw terminals, pigtails, in-line connectors).
  - b) Device ID uniquely identifying the plate/panel keying it to a specific location at the project site, and on the system.

#### F. Quality Assurance

- 1. Samples of plates and panels shall be furnished for review upon the request of the designer.

### 1.7 QUALITY ASSURANCE

- A. Wire, cable, connectors, supplied and installed, shall not exceed the rated capacities and general operating ranges and conditions published by the product’s manufacturer and within the limitations and guidelines
- B. Wire, cables and connectors supplied shall be used only for the purposes of carrying signals of the type(s) for which they are specified and/or approved by the Designer.
- C. Products shall be supplied and installed in accordance with applicable codes.
- D. Pre-approved alternate manufacturers and model numbers notwithstanding, all product supplied of a given type shall be of the same make and model. For example: All non-plenum rated microphone cable supplied for permanent install use be the same make and model across all sections and systems that are relate to this section. This applies to all wire, cable, connectors and other materials furnished under this section.
- E. Where this Contractor chooses to have its sub-contractor(s) furnish its own cabling, it is the responsibility of this Contractor to coordinate the uniform supply of product across all contractors to meet the intent of this section. Should there be technical merit to deviate from this the Contractor shall obtain approval in writing from the designer prior to procuring and installing product.

## **PART 2 PRODUCTS**

### **2.1 MANUFACTURERS**

#### **A. Wire/cable**

1. West Penn Wire and Cable
2. Belden
3. Commscope
4. Cables To Go (Rapid Run)

#### **B. Connectivity**

1. Panel Crafters (Liberty Wire and Cable)
  - a) Internet: [www.panelcrafters.com](http://www.panelcrafters.com), [www.libertycable.com](http://www.libertycable.com)
  - b) Phone: (800) 530-8998
2. Pro-Co Sound
  - a) Internet: [www.procosound.com](http://www.procosound.com)
  - b) Phone: (800) 253-7360
3. Rapco
  - a) Internet: [www.rapco.com](http://www.rapco.com)
  - b) Phone: (800) 325-0266
4. RCI Custom Products
  - a) Internet: [www.rcicustom.com](http://www.rcicustom.com)
  - b) Phone: (240) 912-0130
5. Whirlwind
  - a) Internet: [www.whirlwindusa.com](http://www.whirlwindusa.com)
  - b) Phone: (585) 663-8820
6. Wireworks Corporation
  - a) Internet: [www.whirlwindusa.com](http://www.whirlwindusa.com)
  - b) Phone: (908) 686-7400
7. Cables To Go (Rapid Run)
  - a) Internet [www.rapidrun.com](http://www.rapidrun.com)
  - b) Phone (800) 222-5911

### **2.2 GENERAL**

- A. Contractor shall use these specifications in conjunction with the information provided on the drawings, in related specification sections and from supplied equipment manufacturers to determine the quality, performance and quantity of materials to be furnished.
- B. Wherever there is a conflict between these specifications and the drawings; between different drawings; between parts of these specifications; and between these specifications, the drawings and/or the specific manufacturer recommendations, the Contractor shall presume that the higher quality, higher quantity, and more stringent (the most costly) requirement shall apply. Where the contractor has sought and has

received the approval from the Designer (prior to procuring materials or furnishing work) the potentially less stringent requirement(s) may be considered. A credit of appropriate value will be considered a requirement for the approval of any less stringent solution not approved prior to bid.

- C. Where specific manufacture/brands and models are listed in these specifications and/or on the drawings, the Contractor shall presume that these products set the reference Standard-of-quality.
- D. All furnished cable of a given type shall be of the same manufacture make, model and color, unless otherwise specified and/or approved by the Designer in advance of installation.

## 2.3 INSTRUCTIONAL AUDIO VIDEO SYSTEMS

### A. Standard classroom with single projector

- 1. Instructor local input plate to include:
  - a) Covid model CWP 0003-HDF-PT, HDMI Female 8" Pigtail
  - b) Covid model NEU-NL4MP-ST, NL4MP-ST, Speakon, 4 Pole to Terminal Block
  - c) Covid model CWP 0089-9TBF, DB-09 Female to Terminal Block
  - d) Covid model NEU-NC3MD-S-1-B, NC3MDS1B ; Neutrik 3Pin XLR TB, Male, Black, PM
  - e) Covid model CWP0015-RJ45-6-S, CAT 6 RJ45 PD ; Sheilded (Leviton) Silver
  - f) Covid model CWP 002G-BL, 2-Gang Alum ; Black Power Coat
  - g) Wire control line (DB9) to control both projector and projector screen.
  - h) Provide Speakon connection for amplifier inside the lectern to feed ceiling speakers. All audio connections are served by amplifier inside the lectern.
- 2. Lectern
  - a) Provide Elite Lectern media manager series Heavy-duty caster: (Indigo/Black) to include:
    - 1) Overbridge control console version for Extron MLC Plus 200
    - 2) 12 rack unit front and rear rack cube
    - 3) Quick release doors
    - 4) Flip up shelf
    - 5) Document camera drawer (side depends on location in the room. Away from the wall)
- 3. Control Panel
  - a) Provide Extron MLC Plus 200
    - 1) COM1: projector control
    - 2) COM2: Kramer VP-444 control
    - 3) Relay1: Projector Screen up
    - 4) Relay2: Projector Screen down
- 4. Presentation Scaler
  - a) Provide Kramer VP-444

- 1) HDMI 1 – in room PC
- 2) HDMI 2 – BYOD (Solstice Pod)
- 3) HDMI 3 – HDMI to HDMI (podium top)
- 4) HDMI 4 – HDMI to DisplayPort (podium top)
- 5) HDMI 5 – HDMI to mini DisplayPort (podium top)
- 6) HDMI 6 – HDMI to USB C (podium top)
- 7) PC1 – VGA with audio (podium top)
5. Additional equipment:
  - a) Desktop mount LCD display arm for HP E230T touch monitor
  - b) Middle Atlantic IP Link Power switch (RLNK-915R)
  - c) Extron XPA U 2002 SB amplifier
  - d) Logitech R400 2.4Ghz Wireless powerpoint presenter
  - e) Extron flatfield FF220T ceiling speaker pair (white) or equivalent
  - f) Netgear ProSafe Plus 8 port gigabit ethernet switch with 4 POE ports (MLC Plus 200 and BYOD connects to this switch)
  - g) HP E230T touch screen (connect directly to 2nd output of PC)
  - h) Sony VPL-PHZ12 laser 3LCD multimedia projector
  - i) Chief KITPS003 universal projector mount kit (6" pipe) or equivalent
  - j) Security alarm (Sonic Alarm – need to be keyed the same as rest of campus)
  - k) Acoustic Magic III microphone
  - l) Solstice Pod (BYOD) with 3 year warranty
6. Cabling (Wall to Projector)
  - a) HDMI cable (Liberty hybrid HDMI cable or equivalent) to HDMI connection of projector
  - b) DB9 Serial to serial connection of projector
  - c) Speaker cable on speakon connector (to speaker)
  - d) XLR connector to 3.5mm cable (to Acoustic Magic mic)
7. Cabling (Wall to Lectern) Provide 10-15ft umbilical cord
  - a) HDMI (24 gauge or better with locking mechanism such as Kramer HDMI cables) – to Kramer VP-444 scaler (output1)
  - b) DB9 serial M/M – to MLC Plus controller
  - c) 3pin XLR to 3pin XLR for microphone to Microphone splitter input
  - d) Speakon connector on one end and barewire on another for connecting to amplifier
8. Cabling (Inside the Lectern)
  - a) HDMI to DisplayPort (3ft) – PC to Scaler HDMI 1 input
  - b) HDMI to HDMI (3ft) from scaler (HDMI 2 input) to BYOD (Solstice Pod)
  - c) HDMI to HDMI (6ft)– from scaler (HDMI 3 input1) to table top
  - d) HDMI to Display Port (6ft)– from scaler (HDMI 4 input) to table top
  - e) HDMI to mini Display port (6ft)– from scaler (HDMI 5 input) to table top
  - f) HDMI to USB-C (6ft) from scaler (HDMI 6 input) to table top

- g) VGA with 3.5mm audio (6ft) from scaler (PC1) to table top (audio need to be routed to VP-444)
- h) XLR Female to 3.5mm (2) to connect the mic splitter (output 1) to instructor PC and output 2 to Audio Technica 3.5mm to USB adapter (mic)
- i) HDMI to DisplayPort (10ft)– from scaler output 2 to HP E230T touch screen (or VGA to VGA depending on what is available on PC for 2nd video output)
- j) USB3B to USB 3A cable (10ft) – from PC to HP E230T touch screen
- k) USB3A Male to USB3A Female extension cable (6ft) – from PC to table top
- l) USB3A Male to USB3A Female extension cable (6ft)– from Audio Technica USB adapter to table top (mark as Microphone)
- m) 3.5mm to bare wire – from Audio Technica USB adapter audio out to HDMI2 audio of scaler
- n) 3 conductor bare wire to serial connector – for connecting the scaler RS232 to Extron Plus 200 control panel COM2 port

B. Standard classroom with cameras

- 1. Instructor local input plate to include:
  - a) 1 HDMI to HDMI with pigtail – for connection to Sony VPL-PHZ12 projector
  - b) 4 shielded CAT6 coupler – for connection to projector, instructor camera, student camera, and Shure MXA910 ceiling mic
  - c) Speakon (F Neutek) connector – for speaker connection
  - d) DB9 connector – for connection to projector control
  - e) (NOTE: Wires 2,3,5 of DB9 connector will be fore projector control and 6,7, 8 for projector screen control.)
  - f) The Speakon connection is for connecting the amplifier inside the podium to the speakers on the ceiling. All audio input will be from the source to Kramer VP-444 scaler/switcher inside the podium and the audio output from scaler/switcher to the amplifier.
- 2. Lectern
  - a) Provide Spectrum Lectern media manager series Heavy-duty caster: (Indigo/black) to include:
    - 1) 12 rack unit front and rear rack cube
    - 2) Quick release doors
    - 3) Flip up shelf
    - 4) Document camera drawer (side depends on location in the room. Away from the wall)
- 3. Control Panel
  - a) Provide Extron IPCP Pro 555
    - 1) COM1 – Projector
    - 2) COM2 – Kramer VP-444
    - 3) COM3 – HDMI switcher (camera source selection)
    - 4) COM4 –

- 5) COM5 – instructor camera
- 6) COM6 – student camera
4. Touch Panel
  - a) Provide Extron TLP Pro 725M with angle mount
5. Scaler/Switcher
  - a) Provide Kramer VP-444 Presentation Scaler
    - 1) HDMI 1 – in room PC
    - 2) HDMI 2 – BYOD (Solstice Pod)
    - 3) HDMI 3 – HDMI to HDMI (podium top)
    - 4) HDMI 4 – HDMI to DisplayPort (podium top)
    - 5) HDMI 5 – HDMI to mini DisplayPort (podium top)
    - 6) HDMI 6 – HDMI to USB C (podium top)
    - 7) PC1 – VGA with audio (podium top)
6. Microphone
  - a) Provide Shure MXA910
7. Additional equipment:
  - a) Middle Atlantic IP Link Power switch (RLNK-915R)
    - 1) Input 1 – PC (always on)
    - 2) Input 2 – Kramer VP-444
    - 3) Input 3 – amplifier
    - 4) Input 4 – instructor monitor
    - 5) Input 5 – BYOD (Solstice Pod)
    - 6) Input 6 – Network switch
    - 7) Input 7 – Extron SW2 HD 4K switcher
    - 8) Input 8 – power strip for Extron DTP330Rx
  - b) Extron XPA U 2002 SB amplifier
  - c) Extron MLA VC10 Plus (for controlling volume for amplifier through IPCP Pro)
  - d) Logitech R400 2.4Ghz wireless PowerPoint presenter
  - e) Extron flatfield FF220T ceiling speaker pair or equivalent
  - f) Netgear ProSafe Plus 8 port gigabit ethernet switch with 4 POE ports (For touch panel, Solstice, and other AV gear use only. Instructor PC will need dedicated network port on the wall.)
    - 1) POE port 1 – Extron TLP touch panel
    - 2) POE port 2 – Shure MXA910
    - 3) POE port 3 – Middle Atlantic IP Link power switch
    - 4) POE port 4 – Extron IPCP
    - 5) Port 5 – Kramer VP-444
    - 6) Port 6 – Projector LAN
    - 7) Port 7 – Solstice Pod
    - 8) Port 8 – AV network jack
  - g) HP E230T touch screen (connect directly as 2nd video output from the PC)
  - h) Sony VPL-PHZ12 laser 3LCD multimedia projector

- i) Chief KITPS003 universal projector mount kit (6" pipe) or equivalent
  - j) Solstice Pod (BYOD) with 3 year warranty
  - k) Aver TR530 Auto tracking camera as Instructor camera
  - l) Sony SRG-120DH PTZ camera as student camera
  - m) 2 Extron DTP330Tx (for instructor and student camera – mounted with the cameras)
  - n) 2 Extron DTP330Rx (for cameras inside podium)
  - o) Extron SW2 HD 4K switcher (for managing camera selection)
  - p) Magewell USB Capture HDMI 4K Plus
  - q) Dante to USB adapter for microphone input (via Netgear switch) to the PC
8. Cabling (Wall to Projector)
- a) HDMI to HDMI cable from wallplate to projector
  - b) Serial cable from wallplate to projector (serial port) (pins 2,3,5) and projector screen (pins 6,7,8)
  - c) Speaker wire from Speakon to speakers
  - d) Shielded CAT6/CAT7 cable from wallplate to projector LAN jack
  - e) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Tx Instructor camera
  - f) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Tx student camera
9. Cabling (Wall to Lectern) Provide 10-15ft umbilical cord
- a) HDMI to HDMI from wallplate to Matrix switcher HDMI 1 output
  - b) Shielded CAT6/CAT7 cable from wallplate to Netgear switch (non-POE port) for projector LAN
  - c) Shielded CAT6/CAT7 cable from wallplate for Instructor camera (Extron DTX330Rx)
  - d) Shielded CAT6/CAT7 cable from wallplate for student camera (Extron DTX330Rx)
  - e) Shielded CAT6/CAT7 cable from wallplate to Netgear switch (POE port) for Shure MXA910 microphone
  - f) Serial cable from wallplate to IPCP Pro 555 controller COM1 for projector and screen control (NOTE: Wires 2,3,5 of DB9 connector will be for projector control and 6,7, 8 for projector screen control.)
  - g) Speaker cable from Speakon connector to speakers
10. Cabling (Inside the Lectern)
- a) HDMI to Display port (3ft) cable – PC to matrix switch
  - b) HDMI to Display port (10ft) cable – PC to touch monitor
  - c) HDMI to HDMI (3ft) cable – Solstice Pod to Matrix Switcher
  - d) HDMI to HDMI (6ft) cable – to table top
  - e) HDMI to Display port (6ft) cable – to table top
  - f) HDMI to mini DP (6ft) cable – to table top
  - g) HDMI to USB-C (6ft) cable – to table top

- h) HDMI to HDMI (3ft) cable – HDMI switch for camera to Magewell
- i) HDMI to HDMI (3ft) cables -for the 2 Extron DTX330Rx to HDMI switcher
- j) Shielded CAT6/CAT7 cable (3 ft) from Dante to USB adapter to network switch
- k) CAT6/CAT7 (6ft) cable – Touch panel to network switch POE port
- l) NOTE: Typical location of the wallplate and power/data connections is on the side of the wall where the projector screen/large display are located and on the side that is furthest from the entrance to the room. Location of the podium will be closer to the wall

C. Distance Education Classroom

- 1. Instructor local input plate to include:
  - a) 1 HDMI to HDMI with pigtail – for connection to 85” display
  - b) 5 shielded CAT6 coupler – for connection to 65” display, 32” display, instructor camera, student camera, and Shure MXA910 ceiling mic
  - c) Speakon (F Neutek) connector – for speaker connection
  - d) DB9 connector – for connection to 85” display (Sony FW-85BZ35F) serial connector
  - e) DB9 connector – for connection to 65” (LG UT640S0UA) display serial connector
  - f) DB9 connector – for connection to 32” (NEC E327) display serial connector
  - g) (NOTE: DB9 connectors for 65” and 32” display serial connectors can be replace with 1 CAT6/CAT7 connection. Wires 1,2,3 for 65” display and 6,7,8 for 32” display for 2,3,5 on serial respectively.)
  - h) Need to mount on wall in front of the room where the 85” display will be mounted. Wall plate will be mounted on the side of the wall away from the door to minimize it to become tripping hazard.
  - i) The Speakon connection is for connecting the amplifier inside the podium to the speakers on the ceiling. All audio input will be from the source to DTP Crosspoint 84 4K matrix switcher inside the podium and the audio output from matrix switcher to the amplifier.
- 2. Lectern
  - a) Provide Spectrum Honors Lectern to include:
    - 1) Flip-up shelf
    - 2) Power module
    - 3) Removable cube rack rail mounting (12RU front and 12RU rear)
    - 4) Flat panel monitor arm
- 3. Control Panel
  - a) Provide Extron IPCP Pro 555
    - 1) COM1 – 85” display
    - 2) COM2 – 65” display
    - 3) COM3 – 32” display
    - 4) COM4 – DTP CrossPoint 84 4K

- 5) COM5 – instructor camera
- 6) COM6 – student camera
- 4. Touch Panel
  - a) Provide Extron TLP Pro 725M with angle mount
- 5. Matrix Switcher
  - a) Provide Extron CrossPoint 84 4K Matrix Switcher
    - 1) Inputs:
      - 2) HDMI 1 – PC
      - 3) HDMI 2 – Solstice Pod
      - 4) HDMI 3 – HDMI to HDMI cable (podium top)
      - 5) HDMI 4 – HDMI to DP cable (podium top)
      - 6) HDMI 5 – HDMI to Mini DP cable (podium top)
      - 7) HDMI 6 – HDMI to USB-C cable (podium top)
      - 8) HDMI 7 – shielded CAT6/CAT7 cable (to wallplate for instructor camera)
      - 9) HDMI 8 – shielded CAT6/CAT7 cable (to wallplate for student camera)
    - 10) Output:
      - 11) HDMI 1 – 80” display
      - 12) HDMI 2 – camera source to PC
      - 13) HDMI 3 – Shielded CAT6/CAT7 cable (to wallplate for 65” display)
      - 14) HDMI 4 – Shielded CAT6/CAT7 cable (to wallplate for 32” display – camera confidence monitor)
    - 15) Audio out:
      - 16) Audio 1 – to amplifier (XPA U 2002 SB)
- 6. Microphone
  - a) Provide Shure MXA910
- 7. Additional equipment:
  - a) Middle Atlantic IP Link Power switch (RLNK-915R)
    - 1) Input 1 – PC
    - 2) Input 2 – Extron DTP CrossPoint 84 4K
    - 3) Input 3 – amplifier
    - 4) Input 4 – instructor monitor
    - 5) Input 5 – BYOD (Solstice Pod)
    - 6) Input 6 – Network switch
    - 7) Input 7
    - 8) Input 8
  - b) Extron XPA U 2002 SB amplifier
  - c) Extron MLA VC10 Plus (for controlling volume for amplifier through IPCP Pro)
  - d) Logitech R400 2.4Ghz wireless PowerPoint presenter
  - e) Extron flatfield FF220T ceiling speaker pair or equivalent
  - f) Netgear ProSafe Plus 8 port gigabit ethernet switch with 4 POE ports (For touch panel, Solstice, and other AV gear use only. Instructor PC will need dedicated network port on the wall.)

- g) HP E230T touch screen (connect directly as 2nd video output from the PC)
  - h) Chief KITPS003 universal projector mount kit (6" pipe) or equivalent
  - i) Solstice Pod (BYOD) with 3 year warranty
  - j) Aver TR530 Auto tracking camera as Instructor camera
  - k) Sony SRG-120DH PTZ camera as student camera
  - l) Instructor PC (to be provided by ISU but funded through the overall project budget)
  - m) 2 Extron DTP330Tx (for instructor and student camera – mounted with the cameras)
  - n) 2 Extron DTP330Rx (for 65" and 32" displays – mounted behind the displays)
  - o) Dante to USB adapter for microphone input (via Netgear switch) to the PC
8. Cabling (Wall to Projector)
- a) HDMI to HDMI cable from wallplate to 85" display (HDMI 1)
  - b) Serial cable from wallplate to 85" display (serial port)
  - c) Serial cable from wallplate to 65" display (serial port)
  - d) Serial cable from wallplate to 32" display (serial port)
  - e) Speaker wire from Speakon to speakers
  - f) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Tx Instructor camera
  - g) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Tx student camera
  - h) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Rx 65" display
  - i) Shielded CAT6/CAT7 cable from wallplate to Extron DTX330Rx 32" display
9. Cabling (Wall to Lectern)
- a) HDMI to HDMI from wallplate to Matrix switcher HDMI 1 output
  - b) Shielded CAT6/CAT7 cable from wallplate for Instructor camera
  - c) Shielded CAT6/CAT7 cable from wallplate for student camera
  - d) Shielded CAT6/CAT7 cable from wallplate for 65" display
  - e) Shielded CAT6/CAT7 cable from wallplate for 32" display
  - f) Shielded CAT6/CAT7 cable from wallplate to Netgear switch (POE port) for Shure MXA910 microphone
  - g) Serial cable from wallplate to IPCP Pro 555 controller COM1 for 85" display control
  - h) Serial cable from wallplate to IPCP Pro 555 controller COM2 for 65" display control
  - i) Serial cable from wallplate to IPCP Pro 555 controller COM3 for 32" display control
  - j) (NOTE: Serial cable for the 65" and 32" displays can be changed to CAT6/CAT7 cable. Using 1,2,3 for 65" display control and 6,7,8 for 32" display control to replace 2,3, 5 respectively.)

- k) Speaker cable from Speakon connector to speakers
- 10. Cabling (Inside the Lectern)
  - a) HDMI to Display port (3ft) cable – PC to matrix switch
  - b) HDMI to Display port (10ft) cable – PC to touch monitor
  - c) HDMI to HDMI (3ft) cable – Solstice Pod to Matrix Switcher
  - d) HDMI to HDMI (6ft) cable – to table top
  - e) HDMI to Display port (6ft) cable – to table top
  - f) HDMI to mini DP (6ft) cable – to table top
  - g) HDMI to USB-C (6ft) cable – to table top
  - h) HDMI to HDMI (3ft) cable – HDMI switch for camera to Magewell
  - i) Shielded CAT6/CAT7 cable (3 ft) from Dante to USB adapter to network switch
  - j) CAT6/CAT7 (6ft) cable – Touch panel to network switch POE port

### **PART 3 EXECUTION**

#### **3.1 GENERAL**

- A. Provide all systems equipment, cabling, terminations, and software complete and functional as indicated and as recommended by the manufacturer. See drawings for more information.
- B. Connection Plates
  - 1. Secure all plates with oval-countersink head Phillips drive machine screws.
  - 2. Terminate and mount all connector plates at locations where shown on plans.
  - 3. Install plates square and plumb.
  - 4. Where décora-style jack frames are used, secure jack frames so they are installed secure and flush to plate, without movement
  - 5. Permanently label all plate connections on the front of the plate. Custom plates shall be fabricated by one of the listed manufacturers and may not be Contractor fabricated without pre-bid approval.

#### **3.2 CABLE SELECTION**

- A. Where the drawing(s) or related specification(s) identify the use of specific products, the Contractor shall furnish the products specifically identified.
- B. Where the drawing(s) or related specifications(s) identify the use of a general classification of product, the Contractor shall furnish one or more the products with the referenced classification. Where multiple products are included under the classification, the contractor shall use the criteria or performance guidelines in this specification and in the related specification to determine which product shall be provided.
- C. Where the drawing(s) or other specification sections do not identify a product model, or specific product type, the contractor shall utilize this specification section,

equipment manufacturer recommendations, and industry references and standards to determine which products to provide.

### 3.3 CABLE INSTALLATION

#### A. Isolation and Balancing transformers:

1. Transformers shall be wired so as to provide a balanced, RF interference and ground-loop free signal transmission audio path between plates.
2. Transformer shall be provided with appropriate length conductors added to them to permit secure connection to connectors.
3. Transformer case shall be insulated from ground using a piece of appropriately sized and applied piece of heat shrinkable tubing.

#### B. Cable Separation

1. Cables carrying different signals of different nominal operating level shall be kept separated to reduce the risk of undesirable cross-talk interference between cables.
2. As a general rule, for each 25dBV difference in nominal level between cables, Contractor shall provide 6 inches of separation between cables. For example: cables with a 90dBV level difference shall be separated by at least 18 inches (where 0dBV=1Volt).
3. Contractor shall provide additional separation as determined necessary to prevent or remedy any crosstalk which adversely affects the performance and usability of the system or that exceeds specific crosstalk performance outlined in these specifications.

#### C. Cable and Conductor Identification

1. Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.
2. All cables shall be labeled at both ends using computer generated type-written permanent self laminating wire labels. Cables should clearly correlate to cabling as shown on the installation and record drawings.

#### D. Drain wire and shield preparation

1. Non-insulated conductors (typically the shield and/or shield drain wire) that are an integral part of a multi-conductor cable shall be individually insulated as they exit the jacket of the cable. Apply high-temperature heat shrinkable plastic tubing of the appropriate size over the conductor.
2. Unless otherwise required for conductor color code coordination contractor shall use Green color heat shrink. White and Clear may be used where necessary to coordinate with other conductors.

#### E. Grounding and bonding

1. As a matter of standard practice, the non-signal carrying shield drain wire of audio cables shall be “grounded” at one end only and left floating from ground at the other.

2. Un-terminated shields and drain wires shall not be cut off. Rather these conductors should be insulated and prepped for termination but then folded back and secured on the cable. These conductors shall remain intact reserved for future use and for selective use in remedying grounding anomalies.

### 3.4 LABELING

A. All wires and cables shall be labeled with permanent and unique numeric/alpha - numeric labels.

1. All cables shall be labeled behind the plate
2. Cables shall be labeled within 3-6 inches from point of termination.
3. Use computer and laser-printer generated self-laminating labels. Nomenclature shall be bold type and clearly legible.
4. Record cable labeling on as-built drawings.
5. Audio, Video and Control cables that originate and end within the same room may use the same may be labeled in a "typical" fashion that is consistent with other rooms wired identically.
6. Cables that begin in one room and end in another room shall be uniquely labeled

B. Where not specified or shown on the drawings, the Contractor shall submit it desired labeling scheme for review and approval. Contractor shall make any adjustments to the labeling scheme directed by the Designer. Nomenclature used for labeling may vary by system.

### 3.5 TERMINATION INSTALLATION

A. Assembly

1. Devices with through mounting holes shall be secured to plates/panels using threaded machine screws. Pop rivets are not acceptable.
  - a) Phillips drive flat-head countersink screws shall be used where the device manufacturer provides a countersunk through mounting hole. The size of the head shall match the size of the countersink. Screw head shall not stand proud of the countersink and no sharp exposed edges of the screw shall exist.
  - b) Philips truss head machine screws shall be used for mounting devices without countersunk mounting holes
  - c) Thread-lock compound shall be applied to screw threads used to secure devices to the plate/panel. Low-strength blue Loctite™ or equal shall be used.
2. Devices designed to be mounted without the use of through mounting holes shall be secured using the means expressly provided and/or recommended by the device manufacturer.
3. All devices shall be mounted parallel to the edges of the plate/panel.
4. All devices shall be secure and with no movement or rotation other than that which is part of the intended assembly or device design.

B. Assembly Wiring

1. Wiring shall be neatly and professionally attached to all devices. Appropriate strain relief techniques shall be applied to all pigtails to ensure zero mechanical strain on device connections.
2. Different color wires shall be used in the assembly to aid in identification of circuits. Clearly legible and permanent labels shall be affixed to cables and conductors to aid in identification of circuit and signal paths.

C. Component Mounting

1. Components that are part of plate/panel assembly shall be securely, neatly, and professionally attached.
2. Custom mounting brackets and standoffs shall be used where applicable.

D. Mounting

1. Plate/Panels shall be mounted plumb and square and shall be securely attached to substructure and/or back box.

3.6 ACCEPTANCE TESTING

- A. In the presence of the Designer the Contractor shall demonstrate the presence of all specified equipment, cabling and installation methods. The Contractor shall demonstrate the operation of the system and shall be prepared to make any electronic, physical or software related adjustments to the system or any of its components to the satisfaction of the Designer, as required to achieve full compliance with the specifications.
- B. The contractor shall have available at the project site test equipment, cables, tools and personnel necessary to demonstrate full compliance with these specifications. The Contractor shall have presented a copy of the most up-to-date as-built documentation by this time.
- C. This Contractor shall provide all required labor services required by the Designer to completely verify and test the systems in the presence of the Designer.
- D. Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
- E. Should the Designer be required to return to the project site to perform acceptance testing more the once, the Contractor shall be responsible for additional costs incurred by Designer, up to a maximum of \$1500 per day, plus travel and expenses.

3.7 DEMONSTRATION AND TRAINING

- A. Contractor shall furnish training of the owner's staff (educators) covering the intent and use of all products furnished on this section. Contractor shall furnish minimum of (24) Hours of training. Contractor shall assume that minimum of (8) independent trips to the project site will be required.
  1. Training shall cover the following:
    - a) Use and operation of the Smart Boards.
    - b) Showing the educators where the specialty plates are within their rooms

- c) Hands on demonstration of hooking up equipment to the specialty plates, including passing of signals through all signal paths and viewing/listening to signals on the location display/audio system.

### 3.8 **C**LOSEOUT DOCUMENTATION

- A. Datasheets for each and every cable and custom plate/panel assembly shall be included in the record documents for the project. All information required under Submittals as well as any as-built changes shall be clearly and concisely reflected on this datasheets.
- B. Datasheets shall be assembled into the O&M manual for the specific systems and section to which they apply.

**END OF SECTION 27 41 00.00**

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## SECTION 280500 – COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

### PART 1 - GENERAL

#### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Division 28 Specifications and Drawings.

#### 1.02 SUMMARY

- A. Basic materials, methods and installation guidelines applicable to the work of all Division 28 documents.
- B. The information included in this Section apply too and are additional requirements for all of Division 28 documents.
- C. Thoroughly review entire bid documents, including all drawings and specifications prior to bidding and include all indicated work in bid.

#### 1.03 REQUIREMENTS

- A. Project Coordination
  - 1. Commence coordination immediately upon award of contract. Coordination includes providing and extracting related information to and from other trades for review. Failure to coordinate in a timely manner shall not result in any subsequent additional reimbursement, special allowances or additional construction time being made for any facet of the project. Work fabricated or installed before properly coordinating with all other trades shall be done at the Contractor's own risk.
  - 2. Work in harmony with all building trades, so as not to cause any delays. Sequence, coordinate, and integrate installations of communications materials and equipment with all other applicable trades for efficient flow of the Work. In addition, contact and coordinate/facilitate work of local communications service providers for incoming communications services. Execute connections with local services providers complete as indicated.
  - 3. The drawings indicate the approximate location and arrangement of required work. The drawings shall be followed as closely as possible in coordination and in execution of the work.
  - 4. Participate in coordination efforts and in preparation of coordination drawings prior to fabrication or installation of any equipment, materials, etc. Coordinate actual clearances of all installed equipment.
  - 5. Conflicts in equipment and materials shall be corrected prior to installation. Should there be a conflict with the drawings of other trades, work with the trades to correct the conflict while coordinating the project. If the conflict cannot be resolved, refer the matter to the owner's representative for a final decision as to method or material. Refer to drawings of all other trades for details, dimensions and locations of other work and route their work so

as not to conflict with any other branch. Any work installed or equipment placed in position by this contractor creating a conflict shall be readjusted to the satisfaction of the owner's representative at the expense of this contractor.

6. All products furnished of a given type shall be by a single manufacturer; shall bear the same brand name; shall be of the same finish color and texture; and shall be from the same product model series, unless otherwise noted.
7. Plans are diagrammatic indicating design intent and indicating required size, points of termination and, in some cases, suggested routes of raceways, etc. However, it is not intended that drawings indicate fully coordinated conduit routing, all necessary offsets, etc. Provide all cable assemblies, etc. as straight as possible and symmetrical (perpendicular to or parallel with) with architectural items and in a consistent elevation. Do not provide work installed diagonal to building members.

B. Shop Drawings, Product Data, and Samples

1. Provide complete master material list.
2. Provide the following information for each product:
  - a. The manufacturer's name (Brand) and full model number.
  - b. Product Information Sheets "Datasheets": Include catalog information, sizing, and technical data on each item to be used on the Project.
  - c. Each product datasheet must reference the specific paragraph for which the product is being submitted. Each product must be listed in the exact same order as it appears in the Section for which the products are being submitted.
  - d. Datasheets shall each include a clearly identifiable label applied in upper corner of each sheet that clearly references the specification section and drawing (as applicable) to which it applies. Labels shall be consistently affixed in the same location on all sheets unless the labels will obstruct pertinent technical information.
3. All datasheets shall be original manufacture datasheets, first generation printed copies of manufacturer's electronic datasheet (i.e. printed copy of a PDF file), or high quality photocopy of original manufacturer's datasheets.
4. Where datasheets depict multiple products, versions or options, the Contractor shall highlight (indicate with an arrow) all applicable model(s), version(s) and option(s) applying to the specific product the Contractor will be providing. Exact catalog number must be indicated. The submitted items must be from "approved materials" as specified in each Specification Section.
5. Do not combine with submittals from any other Division.

C. Operation and Maintenance Manuals

1. Prepare Operations and Maintenance Manuals in accordance with Division 1 Section "Maintenance and Operation." In addition to the requirements specified in Division 1, provide additional information as detailed in each Section and include the following information for equipment items:
  - a. Contractor shall submit prior to 50 percent job completion four maintenance manuals. Manuals are to indicate all information relative to maintenance and operating instructions for all new electrical equipment.
  - b. Operations and Maintenance (O&M) manuals shall be provided for each item of equipment. O&M submittals shall be submitted in expandable 3-ring binders. Binders shall contain a sufficient number of dividers to permit an orderly filing of submittals. Each divider shall be labeled as to contents. O&M submittals shall include but not be limited to the following:

- 1) Installation instructions and schematic drawings.
- 2) Operating and maintenance instructions.
- 3) Complete parts list with manufacturer's model numbers.
- 4) Complete set of approved shop drawings.
- 5) Complete wiring diagrams showing all connections and internal wiring diagrams of all equipment, including module diagrams. Factory typical wiring diagrams are not acceptable.

D. Building Codes:

1. National Electrical Code (NFPA 70)
2. Life Safety Code (NFPA 101)
3. Uniform Building Code (Or adopted State Code)
4. Federal Communications Commission (FCC) Part 68
5. State specific agencies:
  - a. Administrative Building Council
  - b. State Board of Health
  - c. State Fire Marshal
6. Local Codes (City, County, etc.)
7. Local Utility Company requirements

E. Standards

1. American National Standards Institute/Telecommunications Industry Association – ANSI/TIA 568C Commercial Building Telecommunications Cabling Standard.
2. American National Standards Institute/Telecommunications Industry Association – ANSI/TIA 569D Commercial Building Standard for Telecommunications Pathways and spaces.
3. American National Standards Institute/Telecommunications Industry Association – ANSI/TIA 606B The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.
4. American National Standards Institute/Telecommunications Industry Association – ANSI/TIA 607C Commercial Building Grounding and Bonding Requirements for Telecommunications.
5. American National Standards Institute /Building Industry Consulting Services International – ANSI/BICSI 005-2016, Electronic Safety and Security (ESS) System Design and Implementation Best Practices.
6. ASIS – Security Management Standard: Physical Asset Protection (PAP)
7. ASIS – Facilities Physical Security Measures Guideline (FPSM)

F. Permits

1. Contractor shall obtain and pay for all permits or certificates of inspection and approval required for his branch of the work.
2. Permits shall be posted in a prominent place at the building site properly protected from weather and physical damage.

G. Definitions

1. Wherever the word “Install” appears on the drawings or in these Division 28 specifications it shall mean to supply all labor, tools and incidental materials necessary to handle, store,

- mount, terminate, program, configure and adjust product as necessary to fulfill project requirements.
2. Wherever the word "Provide" appears on plan drawings or in Division 28 specifications, it shall be interpreted to mean that the Contractor shall "Furnish and Install", including all necessary accessories, miscellaneous materials and labor necessary to render the respective system fully operational.
  3. Wherever the word "Work" appears in Division 28 specifications or on communication technology drawings, it shall be interpreted to mean any and all labor, materials, accessories, services, etc. necessary to fulfill project requirements.
  4. Wherever the word "Furnish" appears on the drawings or in these Division 28 specifications it shall mean to supply the specified labor or specified product, including all associated shipping, storage and warranty expenses.
  5. Wherever the words "Site", "Project Site", or "Premises" appears in Division 28 specifications or its related drawings, it shall be interpreted to mean all real estate, buildings and structures where work will be performed and where products will be installed and reside.
  6. Wherever the phrase "Standard of Quality" appears in Division 28 specifications or its related drawings, the Contractor shall interpret this to mean that the listed Manufacturer and Catalog number for each item has the physical, functional, and operational attributes to provide the designed functionality.

H. Quality Assurance

1. Contractor shall have a minimum five (5) years experience in the installation of Communication Technology system(s) of similar size, type, scope and contract value.
2. The lead technician(s) on the Project shall have a thorough understanding of the following:
  - a. American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 568B Commercial Building Telecommunications Cabling Standard.
  - b. American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and spaces.
  - c. American National Standards Institute/Telecommunications Industry Association – ANSI/TIA/EIA 606 The Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings.
  - d. American National Standards Institute/Telecommunications Industry Association/Electronics Industry Association – ANSI/TIA/EIA 607 Commercial Building Grounding and Bonding Requirements for Telecommunications.
  - e. American National Standards Institute /Building Industry Consulting Services International – ANSI/BICSI 005-2016, Electronic Safety and Security (ESS) System Design and Implementation Best Practices
  - f. ASIS – Security Management Standard: Physical Asset Protection (PAP)
  - g. ASIS – Facilities Physical Security Measures Guideline (FPSM)
3. Contractor shall be a (factory trained) certified installer for all systems provided in Division 28.
  - a. This minimum requirement shall apply to each Division 28 section independently. If Contractor is incapable of meeting the percent of product value requirement for each section, Contractor shall use a Subcontractor that can meet the percent of product value requirement, in whole, for all products and work of that section for which This Contractor is not qualified.

- ## I. Product Delivery Requirements

- ## J. Product Storage and Handling Requirements

- ## COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

6. Keep products out of the weather and away from construction traffic and debris, including drywall finish dust.
7. Do not exceed structural capacity of the floor or platform on which the products are stored.
8. Until final acceptance of the system, protect all supplied products from damage resulting from moisture, fumes, dirt, dust and debris or any other source of potential damage.
9. Handle all products with care before, during and after installation so as to prevent damage.
10. Replace any products damaged prior to final acceptance with new replacement products.
11. Replacement shall be at Contractor's expense.
12. Contractor is responsible for the safety and good condition of the materials and equipment installed until final acceptance by the Owner.
13. Save original product shipping containers and related packaging materials for major products until final acceptance.
14. Prior to disposal, check with owner to determine if the owner wishes any of the packaging materials.

K. Examination and Preparation

1. Contractor shall visit the Site to familiarize himself with the local conditions under which the work is to be performed and correlate his observations with the requirements of the Contract Documents. No allowance shall be made for claims for concealed conditions which the Contractor, in exercise or reasonable diligence in observations of the Site and review of the local conditions under which the work is to be performed, learned or should have learned of, unless otherwise specifically agreed by Owner and Owner in writing.
2. Before ordering any materials or doing any work, the Contractor shall verify all measurements and be responsible for correctness of same. No extra charge or compensation will be allowed for duplicate work or material required because of an unverified difference between an actual dimension and the measurement or size indicated in the drawings or specifications. Any discrepancies found shall be submitted in writing to the Project Manager and Owner for consideration before proceeding with the work.
3. This Contractor must verify all dimensions locating the work and its relation to existing work, all existing conditions and their relation to the work and all man made obstructions and conditions, etc. affecting the completion and proper execution of the work as indicated in the Contract Documents.

L. Installation

1. Provide all required labor, materials, equipment and Contractor's services necessary for complete installation of systems required to comply with the requirements of authorities having jurisdiction, as indicated on Drawings, and as specified.
2. Work shall be functional and complete in every detail, including any and all items required to complete the system, whether or not these items have been enumerated or shown on the Drawings.
3. Special attention shall be given to access to working and controlling parts. Adjustable parts shall be within easy reach. Removable parts shall have space for removal.
4. Each Contractor shall be fully knowledgeable of the details of all Work to be performed by other trades and take necessary steps to integrate and coordinate his Work with other trades.
5. Wherever tables or schedules show quantities of materials, they shall not be used as a final count. These figures serve only as a guide for the Contractor. Each Contractor shall be responsible for furnishing all materials on the Drawings or as specified.
6. The Consultant and Owner's Representative have full power to condemn or reject any Work, materials or equipment not in accordance with these Specifications and Construction Drawings or the manufacturer's specifications or drawings approved by the Owner or Consultant.

7. Work or equipment that is rejected shall be removed and replaced to the satisfaction of the Owner at the Contractor's expense. Work or equipment that is rejected shall be so stated in writing by the Owner or Consultant.
8. Such decisions that the Owner or Consultant may make with respect to questions concerning the quality, fitness of materials, equipment, and workmanship shall be binding upon the parties thereto.
9. All Work shall fully comply with these specifications and related Drawings and all manufacturers recommended installation practices.
10. All Work shall be performed with the best practices of the trade for performance, functionality, safety, endurance, and aesthetics.
11. Coordinate ordering and installation of all equipment with long lead times or having a major impact on work by other trades so as not to delay the job or impact the schedule.
12. Where mounting heights are not detailed or dimensioned, install systems, materials and equipment to provide the maximum headroom possible, as appropriate to the application.
13. Set all equipment to accurate line and grade, level all equipment and align all equipment components.
14. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from premises when no longer required.
15. No equipment shall be hidden or covered up prior to inspection by the owner's representative. All work that is determined to be unsatisfactory shall be corrected immediately.
16. All work shall be installed level and plumb, parallel and perpendicular to other building systems and components.
17. Install all equipment and materials in strict accordance with manufacturer's written instructions. Bring any conflicts between the manufacturer's written instructions and these specifications to the attention of the Designer for recommendations.
18. Upon completion of installation of equipment and communication circuitry, energize circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with re-testing.

M. Cutting and Patching

1. Where demolition of existing surfaces are required by the Work, the same shall be restored to at least as good a condition as they were before.
2. Contractor shall be responsible for painting, patching, repairing and replacing any building surface, furnishing, wall/floor/ceiling covering that is damaged or penetrated in the process of performing work on the project site.
3. Additional work required to repair work performed under this Contract shall be at the expense of This Contractor.
4. The Division 28 contractor shall do all cutting as required for the admission of Division 28 work. Unless directed otherwise in field, provide all related patching and painting to match surrounding methods, materials and colors. Any damage done by this contractor to the building during the progress of this contractor's work shall be made good at this contractor's expense.

N. Site Maintenance

1. During the progress of the work, the Contractor shall clean and leave the premises and all portions of the building in a clean and safe condition. This cleaning shall occur on a daily basis.

O. Final Cleaning

1. Clean all parts of the apparatus and equipment. Exposed parts, which are to be painted, shall be cleaned of cement, plaster and other materials and all oil and grease spots shall be removed. Such surfaces shall be carefully wiped and all corners and cracks scraped out.

P. Closeout Requirements

1. Upon the Designer's receipt of and approval of the Contractor's pre-test submittal, the Contractor shall contract the Designer to schedule acceptance testing. Contractor shall allow not less than 10-business days of advance notice to the Owner.
2. In the presence of the Owner, the Contractor shall demonstrate the presence of all specified products, cabling and installation methods. The Contractor shall demonstrate the operation of the system (and any requested sub-component thereof) and shall be prepared to make any electronic, physical or software related adjustments to the system or any of its sub-components to the satisfaction of the Owner, as required to achieve full compliance with the specifications.
3. The contractor shall have available at the project site all test equipment, cables, tools and personnel necessary to demonstrate full compliance with these specifications as determined necessary by the designer.
4. During the acceptance testing the Contractor shall have a clean and fresh copy of the contractor's most up-to-date as-built record documentation, printed to scale.
5. This Contractor shall provide all required labor services required to completely verify and test the systems in the presence of the Owner.
6. Verify that each system, as a whole system, meets these Specifications and complies with all applicable standards.
7. Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense.

Q. Warranties

1. Specified materials and workmanship provided shall be fully guaranteed by the Contractor for one year from the transfer of title via notice of substantial completion against any defects in materials or workmanship.
2. Extended (additional) warranty(s) may be required and will be identified in the individual Specification Section and will be considered additive to this base Contractor Warranty.
3. Requirements for Manufacturer's Warranties, required by a Specification Section, shall run concurrent to this base Warranty by the Contractor but may exceed the Contractor's Warranty Period.
4. Manufacturer's Warranties shall also begin upon Substantial Completion.
5. The Warranty shall begin upon Substantial Completion.
6. This warranty shall in no manner cover equipment that has been damaged or rendered unserviceable due to negligence, misuse, acts of vandalism, or tampering by the Owner or anyone other than employees or agents of the Contractor.
7. The Contractor's obligation under its warranty is limited to the cost of repair of the warranted item or replacement thereof, at the Contractor's option.
8. Insurance covering said equipment from damage or loss is to be borne by the Contractor until full acceptance of equipment and services.
9. Individual specification sections may have additional warranty requirements for the work in that section. The warranty above will cover all materials and work where not covered by an extended warranty listed in the individual specification section.
10. Specified materials and workmanship provided shall be fully guaranteed by the Contractor against any defects in materials or workmanship.

11. Contractor shall provide a full "System Warranty" which shall cover all materials, labor and related product shipping expenses for a period of five years from the date of Owner acceptance.
12. Supplied products with manufacturer's warranties of less than the System Warranty term shall be extended by the Contractor for the full specified term.
13. During this period the Contractor will remedy (at no cost to the owner) any problem with the system, or any of its related components that is the result of defective materials, settings, workmanship, or loss or programming.
14. Any defective items or work shall be removed and replaced at the Contractor's expense to the satisfaction of the owner's representative and the Owner.
15. The period of the Contractor warranty(s) for any items herein are not exclusive remedies, and the Owner has recourse to any warranties of additional Scope given by the Contractor to the Owner and all other remedies available by law or in equity.
16. Additional Warranty requirements may be added by an individual Specification Section.
17. Scope of these extended (additional) warranty(s) will be identified in the individual Specification Section and will be considered additive to this base Contractor Warranty.
18. Requirements for Manufacturer's Warranties, required by a Specification Section, shall run concurrent to this base Contractor Warranty by the Contractor.
19. Manufacturer's Warranties shall also begin on Substantial Completion.

R. Demonstration and Training

1. Each Division 28 section may specify special Training requirements.
2. Training requirements will be for a quantity of hours, allow for multiple trips.
3. If no special requirements are specified in the individual section, provide for 4 hours and 2 trips for basic overview, operation and maintenance information per section.
4. Train Owner's maintenance personnel on the procedures and schedules involved in operating, general troubleshooting, and preventative maintenance of the system.
5. Contractor shall require all attendees to sign-in for each training session. The sign-in form shall summarize the training to be conducted, specification section and subsection being trained on, as well as the starting time and duration of training. Following training, a representative of the owner shall sign the form, acknowledging the same. Contractor shall retain the original copy of these forms and turn over a photo copy of the form to the owner's representative as evidence of training. Training conducted without this official record of training shall not be considered as part of the Contractor's training obligation.
6. Schedule training with the Owner's representative, at least 14 days in advance.

PART 2 - PRODUCTS

2.01 ASSIGNMENT OF MISCELLANEOUS WORK

- A. Excavating and backfilling for telecommunications work shall be by telecommunications contractor.
1. Properly support banks of excavation with safety sheet pile. Install necessary guards. Provide adequate pumping equipment and keep excavation free of water.
  2. Excavate pipe trenches to proper depth. Where rock is encountered, excavate to 6 inches below pipe and refill to 6 inches above pipe with compacted granular fill. Granular fill shall consist of dune sand, gravel or other suitable material containing not more than 10 percent by weight passing #200 sieve and 100 percent passing 1-inch sieve.
  3. Excavation for utilities shall not be backfilled until all required tests are performed and approved by Engineer and the utility company.

4. Whenever underground feeders are run below footings and grade beams, contractor shall backfill the void with poured, steel-reinforced concrete to elevation of bottom of footing or grade beam.
  5. Backfill within building lines shall be made with granular fill or compacted backfill material laid in 6-inch layers and tamped to specified compaction after each layer.
  6. Backfill under paved area shall be made with granular fill compacted backfill material laid in 12-inch layers and tamped to compaction after each layer.
  7. Backfill under open yards or fields shall be made with non-compacted backfill laid in layers not to exceed 24 inches deep. Sand trenches may be allowed to settle naturally and shall be refilled back to grade as required during first year after final acceptance.
  8. Contractor shall refill, regrade and refinish any area that becomes unsatisfactory due to settlement within one year after final acceptance.
  9. Contractor shall verify all existing grades, inverts, utilities, obstacles and topographical conditions prior to any trenching, excavation or underground installation. In event existing conditions are such as to prevent installation in accordance with Drawings, contractor shall immediately notify Engineer.
  10. Provide appropriate plastic marker tape buried directly above underground electric and communication lines continuously along length of lines. Marker tape shall be located 12 inches below finished grade, but no closer than 12 inches above underground lines. Tape shall be a minimum of 6 inches wide.
  11. Refer to Division 31 Section "Earth Moving," for additional requirements. In event of conflict between this section and Division 31 Section "Earth Moving," Division 31 Section "Earth Moving" shall apply, unless otherwise indicated by Engineer.
- B. Provide sleeved penetrations for all cabling access where applicable.
1. Where conduits pass through walls, roofs, ceilings, or floors, contractor shall set sleeves when floors, walls, ceilings or roofs are constructed. If any holes are cut in finished work where sleeves have been omitted, cutting shall be done with a concrete coring machine or other approved means and only with consent of Engineer. All such holes are to be carefully cut and shall not be larger than necessary. These holes are to be entirely covered by escutcheon plates when work is completed. Sleeves shall be made of pipe or rolled sheet steel no lighter than No. 18 gauge.
  2. Where conduits pass through sleeves in exterior walls above grade, annular space shall be caulked with oakum and filled inside and out with non-hardening, waterproof sealant finished off flush with both faces of wall.
  3. Provide penetration seals for all conduits penetrating the building wall below grade.
    - a. Description: The pipe to wall penetration closures shall be "Link-Seal" or equal, as manufactured by PSI/Thunderline Corporation – Houston, TX. Seals shall be modular type, consisting of synthetic rubber shaped to continuously fill the annular space between the pipe and wall opening. After the seal assembly is positioned in the sleeve, the rubber sealing elements shall provide an absolutely water-tight seal between the pipe and wall opening. The seal shall be constructed as to provide insulation between the pipe and wall, thus reducing changes of cathodic reaction between these two members.
    - b. Wall Opening: Provide "Century-Line" sleeves or equal as manufactured by PSI/Thunderline Corporation – Houston, TX. Contractor shall determine the required inside diameter of each individual wall opening of sleeve before ordering, fabricating or installing. The inside diameter of each wall opening shall be sized as recommended by the manufacturer to fit the pipe and Link-Seal to assure a water-tight joint. Sizing (correct Link-Seal model and number of links per seal) may be obtained through manufacturer's catalog. If pipe O.D is non-standard due to coating,

- insulation, etc. consult Thunderline's factory for engineering assistance and recommendation before proceeding with wall opening detail.
- c. Holes through Structural members: Holes required for conduit of size 5-inches and smaller shall be cut in field at expense of this contractor. Obtain structural engineer's approval in writing prior to any cutting.
- d. Pitch Pockets: Required for conduit penetrating roof. Seal sleeves and provide flashing.
- e. Dust Protection: Provide temporary partitions or barriers required to protect existing building or facility. Coordinate necessity and location of such protection with Owner.
- f. Painting of telecommunications cabling and components is not permitted. Notify painting contractor that painting of telecommunications cabling and components is not permitted. Protect cabling as necessary to avoid painting.

## 2.02 MATERIALS AND EQUIPMENT

- A. Equipment shall be new, listed by UL and shall conform to NEMA and ICEA standards.
- B. Materials used for like service shall be by same manufacturer.
- C. All materials and equipment, including any hangers, supports, fastenings or accessory fittings, shall have corrosion protection suitable for atmosphere in which they are installed, whether located indoors or out. Care shall be taken during installation to assure integrity of corrosion protection.
- D. All screws, bolts, nuts, clamps, fittings or other fastening devices shall be made up tight. All bolts, screws, nuts and other threaded devices shall have standard threads and heads so they may be installed and replaced when necessary without special tools.

## 2.03 PRODUCT AND MATERIAL APPROVAL

- A. A Specification followed by one or more manufacturers is limited to those manufacturers. Names of other manufacturers may be submitted for approval to Engineer a minimum of ten (10) days prior to receiving bids. Approval will be issued by Addendum if granted.
- B. A Specification followed by one or more manufacturers and "or approved equal" is open to all equal products or materials; however, Contractor shall supply one of listed manufacturers at no additional cost if Engineer finds substituted product unsatisfactory.

## 2.04 CAULKING AND FIRESTOPPING

- A. In addition to the requirements in Division 07 Section "Penetration Firestopping," comply with this Article.
- B. All raceway and sleeve penetrations of fire barriers shall be sealed to achieve fire resistance equivalent to fire separation.
  - 1. Maintain fire rating per ASTM E-814 and UL 1479.
  - 2. This assembly must also maintain a watertight seal between floor or wall and pipe.

- C. For other penetrations through non-rated walls, partitions, floors and ceilings, caulk the space between raceways and raceway sleeves with non-staining, waterproof gun grade compound. Apply caulking compound by the gun method using nozzles of a proper size to fit the width of joint. Prepare the joint for caulking by packing it tightly with a resilient foam or rope yarn.
- D. Products: Subject to compliance with requirements, provide one of the following:
  - 1. Maintain fire rating per ASTM E-814 and UL 1479.
  - 2. Penetration sealant:
    - a. 3M Brand "Moldable Putty Pads": and "Moldable Putty Stix"
    - b. 3M Brand "Fire Barrier" Caulk, Putty or Penetrating Sealing Systems
    - c. Dow Corning "Fire Stop Foam: and "Fire Stop Sealant" systems
    - d. Insta-Foam Products, Inc. "Insta-Fire Seal Silicone RTV Foam"
    - e. Standard Oil Engineering Materials Company, "Frye Putty"
    - f. Chase technology "Chase Foam #CTC PR-855"
  - 3. Intumescent Sealant for use at openings and sleeves involving flexible cable.
    - a. 3M Brand "Fire Barrier" caulk or putty, FS-195 Wrap Strip and CS-195 Composite Sheet.
    - b. Dow Corning "Fire Stop Intumescent Wrap Strip"
    - c. Fox Couplings, Inc. "The Fox Cast-in-Place Coupling"
  - 4. Performance Characteristic: Firestopping materials shall conform to both Flame (F) and Temperature (T) ratings as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test.
    - a. °F Rating shall be a minimum of one hour but not less than the fire resistance rating of the assembly being penetrated.
    - b. Conduct the fire test with a minimum positive pressure differential of 0.01 inches of water column.
  - 5. Quality Assurance: Installer qualifications – a firm specializing in firestopping installation with not less than two years of experience or trained and approved by firestopping manufacturer.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION OF COMMUNICATIONS SYSTEMS

##### A. General

- 1. All work installed in finished areas shall be concealed.
- 2. Install systems, materials, and equipment to conform with approved documents.
- 3. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.
- 4. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

5. Verify all dimensions by field measurements. Take measurements and be responsible for exact size and locations of all openings required for the installation of work. Proposed dimensions are reasonably accurate and should govern in setting out work. Where detailed method of installation is not indicated or where variations exist between described work and approved practice, direction of the owner's representative on job shall be followed.
6. Workmanship throughout shall conform to the standards of best practice. Marks, dents or finish scratches will not be permitted on any exposed materials, fixtures or fittings. Inside of panels and equipment boxes shall be left clean.
7. Use caution not to exceed the allowed bend radius for respective cables and not to compromise the integrity of the cables during installation by pulling cable management devices too tightly, damaging cables, etc. Raceway/Cabling bending radii shall be minimum as directed by cable manufacturer. Use pulling compound or lubricant, where necessary; compound must not deteriorate conductor or insulation.

B. Cable

1. Provide color-coded jackets to identify different systems.
2. Neatly comb out multiple cable bundled runs to remove tangling and crossing of cables within the bundles. Neatly dress all cable work and provide vertical and horizontal cable management (or other approved method) for properly dressing all work at racks, control panels, backboards etc.
3. Provide spacing between cable bundles to help dissipate heat. Do not cinch cables into tight bundles.
4. Nylon cable ties are not permitted. Bundle cables with "Velcro" style cable straps with a minimum of 1-inch width.
5. All cables shall be supported every 5 feet (or less) and within 12" of device boxes, outlets, racks/cabinets and cable tray.
6. Use separate J-Hook cable support systems for cables belonging to different systems and for cables carrying different operating levels.
7. Loosely secure cables at each J-Hook.
8. Cables shall not be directly or indirectly supported by a suspended ceiling or any other surface, support, material or structure not permissible for this use by all applicable codes and standards.
9. Cables carrying signals of different nominal operating level shall be kept separated to reduce the risk of undesirable cross-talk interference between cables.
10. Keep length of parallel runs to a minimum. Cross cables of different nominal levels at 90 degrees.
11. Provide additional separation as necessary to prevent and remedy any crosstalk.
12. Contractor shall take all precautions necessary to keep low-voltage cable away from sources of EMI and RF interference. Where close proximity is absolutely necessary to satisfactory appearance, performance or installation of the Work, provide all necessary shielding necessary to ensure that ingress interference is minimal and has no negative impact of the Work.
13. Provide a minimum of 12 inches cable slack where terminating at a device outlet to facilitate installation and servicing of devices. Longer working lengths shall be provided as appropriate to the application.
14. All termination types shall correctly match the cable and device termination point. Connectors of the appropriate type, size, color and rating shall be used to match with the mating equipment.
15. Tools as recommended by each specific connector manufacturer shall be used in attachment of all connectors.
16. When spade connectors are the required to be used for audio circuits operating at  $\leq +8\text{dBv}$  nominal, solder type spade connectors only shall be permitted.

17. No more than two spade connectors shall be permitted under a single terminal. Fewer should be used when recommended by the specific manufacturer's equipment or connector.
18. Wire Nuts
  - a. Wire nuts shall not be used in any audio circuit, except when necessary in the following:
    - 1) 25 Voltage Constant-Voltage loudspeaker circuits.
    - 2) 70 Voltage Constant-Voltage loudspeaker circuits.
  - b. Wire nuts shall not be used in any data or voice communications or remote control circuit.
  - c. Wire nuts shall not be used in any circuit which radiates RF energy.
  - d. Contractor must advise and gain prior approval of the Owner for any circuit which the Contractor desires to use wirenuts as the means of termination.
19. Drain Wires, Non-insulated Ground Wires and Shields
  - a. Drain or non-insulated ground conductors shall be insulated with appropriately sized heat-shrinkable insulated sleeving immediately upon exit from the jacket of the cable. Contractor shall use GREEN colored sleeving unless otherwise necessary to resolve specific color coding conflicts on a given cable. This methodology shall apply to ALL methods of termination, including inline connectors, device plates, direct equipment terminations etc... Sleeving shall be applied to twisted and braided shields once the internal conductors have been combed out or otherwise removed from the center of the shield.
  - b. Wherever a cable contains a non-insulated conductor within a jacketed cable, the conductors, as they exit the manufacturer's jacket, shall have a piece of heat shrinkable sleeving applied equally over the jacket and the exposed insulated conductors. The length of this sleeving shall be 1" for all cable diameters of .250" or less. For cables diameters larger than .250" the length of the sleeving shall be approximately equal to 4 times the diameter of the cable jacket. Note: This added sleeving is recommended but not mandatory when cable termination occurs fully within the confines of a fully insulated and strain relieved connector. Black shall be used unless otherwise necessary for specific cosmetic or cable identification purposes.
  - c. A heat-gun of the appropriate temperature, size, type and rating for shrinking the tubing shall be used as recommended by the manufacturer of the sleeving used. Open flame (i.e. matches, cigarette lighters, torches) and direct metal conduction (i.e. soldering iron) methods to shrink the sleeving shall not be permitted. Sleeving which is burnt or otherwise marred shall be removed and replaced.
  - d. There shall not be any non-insulated exposed conductors within a device backbox, junction box, or equipment rack/cabinet.
20. Unused Conductors
  - a. Unused conductors shall not be "clipped" or removed from any jacketed cable. Conductors which are not required or used at the end of a jacketed cable shall be kept intact. Conductors shall be fully insulated from one and other to prevent shorts which could occur at either end of the cable. Conductor ends shall also be insulated to prevent shorts to other conductive materials which could come in contact with the conductor.

- b. Unused conductors shall be kept the same length as the longest conductor of the cable being used.
- c. Attention shall be paid to the proper preparation of all cables and all conductors of these cables. There shall not be nicks to cable jackets, conductor insulation, or the conductors themselves.
- d. Special attention should be paid to nicked conductors. Should a conductor be nicked during preparation or termination the cable shall be reworked/replaced to remove the nick.
- e. Any voice, data, or coaxial cable that is cut, disconnected, or not terminated at both ends shall be completely removed end to end. Any labels at either end shall be erased. Record drawings shall reflect the removal of these cables.

### 3.02 ATTACHING TO BUILDING CONSTRUCTION

- A. Attach supports to structural members (beams, joists, etc.) rather than to floor or roof slabs. Do not attach to ceiling support wires.
- B. Where equipment and raceway are suspended from existing concrete or masonry construction, use expansion shields to attach supports to construction. Expansion shield bolt diameter shall be same size as support rod diameter, hereinafter specified. Expansion shields shall be Star Double, Star Gloxin, Star Loxin or approved equal.
- C. Where existing masonry is not suitable to receive and hold expansion shield or where other means of attachment is advantageous, submit alternate method for approval by Engineer.
- D. Equipment to be installed in groups shall not be mounted directly to masonry or concrete walls. Mount 1- by 1-inch structural channel such as Unistrut, to wall and secure equipment to these channels.
- E. Where raceways are suspended from structural steel building framing or supporting members, provide beam clamps for attaching piping device to building member.
- F. Obtain approval from Owner and structural engineer before cutting or welding to structural members, or before hanging heavy equipment.

### 3.03 ESCUTCHEONS

- A. Provide chrome plated escutcheons on material, leaving and entering walls, floors, ceilings, etc.

### 3.04 EQUIPMENT INSTALLATION

- A. All equipment must be installed such that maintenance and service may be properly accomplished. If necessary, the Owner, at their option, may require the contractor to demonstrate the service on any piece of equipment to determine sufficient service space exists. If the service space is not adequate, the equipment shall be relocated at no additional cost to the Owner such that sufficient service space is achieved.

3.05 OCCUPATIONAL SAFETY & HEALTH STANDARDS

- A. All work shall comply with current requirements of U.S. Department of Labor-Occupational Safety & Health Administration, entitled Occupational Safety and Health Standards; National Consensus Standards and Established Federal Standards.

3.06 DEMOLITION

- A. In addition to the requirements in Division 02 Section "Selective Demolition," comply with this Article.

- 1. Scope of Work: Provide demolition required for removal of systems and equipment made obsolete by this Project and as determined by the Architect/Engineer.
- 2. Work Included:
  - a. Non-destructive removal of systems, materials, and equipment for reuse or salvage as shown on Drawings or requested by Owner.
  - b. Removal of all debris from site and legal disposal of same.
  - c. Removal of all abandoned or obsolete exposed materials and equipment for a clean and finished installation.
  - d. Removal of all abandoned or obsolete raceways, wiring, cabling, or electrical devices of any kind.

- B. Conditions

- 1. Coordination: Adjacent areas need to remain in operation and services to these areas need to be maintained. A schedule will be worked out prior to beginning work and as many criteria for operation as possible will be explained. Contractor cooperation shall be expected in all conditions.
- 2. Phasing:
  - a. Prior to commencing demolition in any area of the work, notify the Owner and Architect/Engineer five (5) working days in advance to insure that no adjacent occupied areas will be disrupted.
  - b. Demolition phasing must be approved by Architect/Engineer prior to commencement of operations.
  - c. Removal of debris and construction traffic will be limited to specified areas. Confirm all operations with Architect/Engineer prior to commencement of work.
- 3. Adjacent Materials:
  - a. During the execution of the work, primary consideration shall be given to protecting from damaging the structure, furnishings, finishes, and the like which are not specifically indicated to be removed and disposed.
  - b. Provide and maintain temporary partitions or dust barriers adequate to keep dirt, dust, noise and other particles from being transferred to adjacent areas.
  - c. Existing items or surfaces to remain which are damaged as a result of this work shall be refinished, repaired, or replaced to the satisfaction of the Architect/Engineer and Owner at no additional cost.

- C. Materials

1. Patching: Materials used for patching shall be in conformance with the applicable sections of the Project Manual. Where materials are not specifically described but required for proper completion of the work, they shall be as selected by the Contractor subject to approval of the Architect/Engineer. Materials used and workmanship shall match surrounding areas as much as possible, unless otherwise directed.

D. Demolition

1. Site Inspection
  - a. The Contract Documents do not propose to show all systems, materials, or equipment existing on the project that will require demolition.
  - b. Before commencing the work of this Section, verify with the Architect/Engineer and Owner all systems, materials, and equipment to be removed and those to be preserved.
2. Scheduling
  - a. Schedule all work in a careful manner with all necessary considerations for public and adjacent areas.
  - b. Avoid interference with the use of adjacent areas and passage to and from these areas.
3. Abandoned Materials and Equipment: Items so indicated on Contract Documents to be removed and not indicated or specified to be saved or retained, shall be demolished, removed, demounted, or disconnected in the best possible manner to ensure that no damage will result to other adjacent items or surfaces to remain.
4. Salvage
  - a. During removal of items so indicated, caution shall be used to eliminate damage to any equipment having salvage value.
  - b. All reusable salvaged material shall remain the property of the Owner and be retained for his inspection. Only items so inspected and rejected by the Owner shall be disposed by the Contractor. All other such items shall be turned over and deposited as directed by the Owner.
5. Disposal and Clean Up
  - a. Areas in which demolition and salvage work is being done shall be cleaned daily.
  - b. Dirt, dust, debris, unsalvageable and reusable items, and the like shall be totally removed from the project site daily. Under no circumstances shall such refuse be allowed to collect for longer periods.
  - c. Refuse shall not be allowed to block, or otherwise impair, circulation in corridors, stairs, sidewalks, or other traffic areas.

END OF SECTION 28 05 00

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SECTION 283111.10 – FIRE ALARM ADDRESSABLE WITH ADDRESSABLE SPEAKER - VISUAL  
PART 1 - GENERAL

1.01 SUMMARY

- A. This Section covers fire alarm systems, including initiating devices, notification appliances, controls, and supervisory devices.
- B. Work covered by this section includes the furnishing of labor, equipment, and materials for installation of the fire alarm system as indicated on the drawings and specifications.
- C. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the following functions:
  - 1. Fire alarm and detection operations
  - 2. Control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.
  - 3. One-way supervised automatic voice alarm operations.

1.02 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: The equipment and service described in this specification are those supplied and supported by SimplexGrinnell.
- B. No Substitutions allowed; must match the Campus fire alarm network systems.

1.03 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.
- B. The work covered by this section is to be coordinated with related work as specified elsewhere in the specifications. Requirements of the following sections apply:
  - 1. Division 26: all sections apply
- C. The system and all associated operations shall be in accordance with the following Guidelines of the following Building Code: UBC IBC
  - 1. NFPA 72, National Fire Alarm Code
  - 2. NFPA 70, National Electrical Code
  - 3. NFPA 101, Life Safety Code
  - 4. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems
  - 5. Other applicable NFPA standards
  - 6. Local Jurisdictional Adopted Codes and Standards
  - 7. ADA Accessibility Guidelines

1.04 SYSTEM DESCRIPTION

- A. General: Provide a complete, non-coded, addressable/conventional, microprocessor-based fire alarm system with initiating devices, notification appliances, and monitoring and control devices as indicated on the drawings and as specified herein.
- B. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary. The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory. System shall be capable of storing dual configuration programs with one active and one in reserve.

Panel shall be capable of full system operation during a new configuration download.

- C. History Logs: The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.
- D. Recording of Events: Record all alarm, supervisory, and trouble events by means of system printer. The printout shall include the type of signal (alarm, supervisory, or trouble) the device identification, date and time of the occurrence. The printout differentiates alarm signals from all other printed indications.
- E. Wiring/Signal Transmission:
  - 1. Transmission shall be hard-wired, using separate individual circuits for each zone of alarm operation as required.
  - 2. System connections for initiating (signaling) circuits and notification appliance circuits shall be Class B.
  - 3. Circuit Supervision: Circuit faults shall be indicated by a trouble signal at the FACP.
  - 4. Provide a distinctive indicating audible tone and alphanumeric annunciation.
- F. Required Functions: The following are required system functions and operating features:
  - 1. Priority of Signals: Alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions.
  - 2. Priority Two, Supervisory and Trouble events have second-, third-, and fourth-level priority respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first.
- G. Annunciate all events regardless of priority or order received.
  - 1. Noninterfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent activations.
- H. Transmission to Remote Monitoring Stations shall be over the Owners Simplex Fire Alarm Network on Owner supplied fiber optic cables.
- I. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP indicating the location and type of device.
- J. General Alarm: A system general alarm shall include:
  - 1. Indication of alarm condition at the FACP.
  - 2. Identification of the device or zone that is the source of the alarm at the FACP.
  - 3. Operation of audible and visible notification devices throughout the building until silenced at FACP.
  - 4. Closing doors normally held open by magnetic door holders.
  - 5. Unlocking designated doors.
  - 6. Shutting down supply and return fans serving zone where alarm is initiated.
  - 7. Closing smoke dampers on system serving zone where alarm is initiated.
  - 8. Initiation of smoke control sequence through the building temperature control system.
  - 9. Notifying the ISU Public Safety Dispatch Center and the Terre Haute Fire Department 911 Center.

- K. Supervisory Operations: Upon activation of a supervisory device such as fire pump power failure, low air pressure switch, and tamper switch, the system shall operate as follows:
  - 1. Activate the system supervisory service audible signal and illuminate the LED at the control unit.
  - 2. Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
  - 3. Record the event in the FACP historical log.
  - 4. Transmission of supervisory signal to the ISU Public Safety Dispatch Center.
  - 5. Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.
- L. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible and visible alarm signals shall cease operation.
- M. System Reset
  - 1. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-arming the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."
  - 2. Should an alarm condition continue, the system will remain in an alarmed state.
- N. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated.
- O. WALKTEST: The system shall have the capacity of 8 programmable passcode protected one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:
  - 1. The city circuit connection and suppression release circuits shall be bypassed for the testing group.
  - 2. Control relay functions associated to one of the 8 testing groups shall be bypassed.
  - 3. The control unit shall indicate a trouble condition.
  - 4. The alarm activation of any initiation device in the testing group shall cause the audible notification appliances to sound a [voice announcement] [code] to identify the device or zone.
  - 5. The unit shall automatically reset itself after signaling is complete.
  - 6. Any momentary opening of an initiating or notification appliance circuit wiring shall cause the audible signals to voice announce the trouble condition.
- P. Analog Smoke Sensors:
  - 1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
  - 2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
  - 3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 sensitivity levels ranging from 0.2% to 3.7%, programmed and monitored from the FACP.

4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements. The reports shall be viewed on a CRT Display or printed for annual recording and logging of the calibration maintenance schedule.
  5. The FACP shall automatically indicate when an individual sensor needs cleaning.
    - a. The system shall provide a means to indicate that a sensor requires cleaning. When a sensor's average value reaches a predetermined value, (3) progressive levels of reporting are provided.
    - b. The first level shall indicate that a sensor is close to a trouble reporting condition and will be indicated on the FACP as "ALMOST DIRTY." This condition provides a means to alert maintenance staff of a dirty sensor without creating a trouble in the system.
    - c. If this indicator is ignored, a second level "DIRTY SENSOR" condition shall be indicated at the FACP and subsequently a system trouble is reported to the ISU Public Safety Dispatch Office. The sensor base LED shall glow steady giving a visible indication at the sensor location. The "DIRTY SENSOR" condition shall not affect the sensitivity level required to alarm the sensor.
    - d. If a "DIRTY SENSOR" is left unattended, and its average value increases to a third predetermined value, an "EXCESSIVELY DIRTY SENSOR" trouble condition shall be indicated at the control unit.
  6. The FACP shall continuously perform an automatic self-test on each sensor which will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a "SELF TEST ABNORMAL" trouble condition.
  7. Multi-Sensors shall combine photoelectric smoke sensing and heat sensing technologies. An alarm shall be determined by either smoke detection, with selectable sensitivity from 0.2 to 3.7 %/ft obscuration; or heat detection, selectable as fixed temperature or fixed with selectable rate-of-rise; or based on an analysis of the combination of smoke and heat activity.
- Q. Programmable bases. It shall be possible to program relay and sounder bases to operate independently of their associated sensor.
- R. Magnet test activation of smoke sensors shall be distinguished by its label and history log entry as being activated by a magnet.
- S. Audible Alarm Notification:
1. By voice evacuation and tone signals on loudspeakers in areas as indicated on drawings.
  2. Automatic Voice Evacuation Sequence:
    - a. The audio alarm signal shall consist of a high-low alarm tone that shall sound continuously until the "Alarm Silence" switch is activated.
  3. The system shall also include the standard ISU tornado warning and all clear message.
  4. All audio operations shall be activated by the system software so that any required future changes can be facilitated by authorized personnel without any component rewiring or hardware additions.
- T. Speaker: Speaker notification appliances shall be listed to UL 1480.
1. The speaker shall operate on a standard 25VRMS or 70.7VRMS NAC using twisted/shielded wire.
  2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.

3. The speaker shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.

U. Manual Voice Paging

1. The system shall be configured to allow voice paging. Upon activation of any speaker manual control switch, the alarm tone shall be sounded over all speakers in that group.
2. The control panel operator shall be able to make announcements via the push-to-talk paging microphone over the pre-selected speakers.
3. Facility for total building paging shall be accomplished by the means of an "All Call" switch.

V. Fire Suppression Monitoring:

1. Water flow: Activation of a water flow switch shall initiate general alarm operations.
2. Sprinkler valve tamper switch: The activation of any valve tamper switch shall activate system supervisory operations.
3. WSO: Water flow switch and sprinkler valve tamper switch shall be capable of existing on the same initiating zone. Activation of either device shall distinctly report which device is in alarm on the initiating zone.

W. Power Requirements

1. The control unit shall receive AC power via a dedicated fused disconnect circuit.
2. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in a normal supervisory mode for a period of 24 hours with 15 minutes of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.
3. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.
4. The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously while incoming power is present.
5. The system batteries shall be supervised so that a low battery or depleted battery condition or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.
6. The system shall support NAC Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control.
7. The system shall support 100% of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.
8. Loss of primary power shall sound a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.

1.05 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections.

1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.

2. Wiring diagrams from manufacturer.
3. Shop drawings showing system details including location of FACP, all devices, circuiting and details of IMS graphic screens.
4. System Power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
5. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location or use of IDC, NAC, relay, sensor, and auxiliary control circuits
6. Operating instructions for FACP.
7. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.
8. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
9. Record of field tests of system.

#### 1.06 QUALITY ASSURANCE

- A. Installer Qualifications: A factory authorized installer is to perform the work of this section.
- B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL), and shall bear the "UL" label.
- C. Exception: Notification Appliance Devices by COOPER Notification (Wheelock) are acceptable.

#### 1.07 MAINTENANCE SERVICE

- A. Maintenance Service Contract: Provide maintenance of fire alarm systems and peripheral equipment for a period of 12 months after substantial completion, using factory-authorized service representatives. Maintenance shall be on a 24/7/365 basis with a guaranteed 4 hour response if the problem is deemed by the Owner to be serious enough to require this level of response. The Owner is knowledgeable of fire alarm system operation and what constitutes a problem serious enough to require the 4-hour response. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.
  1. If the Owner replaces a defective peripheral device from their peripheral device stock the replaced peripheral device shall be provided to the Owner at no additional cost for the Owner's stock replacement provided the peripheral device was not damaged due to misuse or vandalism. The Owner will provide the defective peripheral device that was replaced to the Manufacturer upon request. The Owner's labor costs for the peripheral device replacement will **not** be billed to the Manufacturer.
- B. System Inspection: Prior to the end of the one year warranty the Manufacturer shall provide a complete **panel** inspection, including battery testing, and correct any problems found with the panel and any peripheral equipment showing on the panel as being defective at the time of the panel inspection as a part of the system warranty.
- C. Additional Services: Perform services within the above 12-month period not classified as routine maintenance or as warranty work when authorized in writing. Compensation for

additional services must be agreed upon in writing prior to performing services.

#### 1.08 EXTRA MATERIALS

- A. General: Furnish extra materials, packaged with protective covering for storage, and identified with labels clearly describing contents as follows:
  - 1. Break Rods for Manual Stations: Furnish quantity equal to 15 percent of the number of manual stations installed; minimum of 6 rods.
  - 2. Manual Stations: Furnish quantity equal to 10 percent of the number of units installed, but not less than one.
  - 3. Audio visual and strobe only units: Furnish quantity equal to 10 percent of the number of units installed, but not less than one.
  - 4. Smoke Detectors or Sensors, Fire Detectors, and Flame Detectors: Furnish quantity equal to 10 percent of the number of units of each type installed but not less than one of each type used.
  - 5. Detector or Sensor Bases: Furnish quantity equal to 10 percent of the number of units of each type installed but not less than one of each type.

#### 1.09 SYSTEM PROGRAMMING

- A. Provide three (3) years of system reprogramming including FACP, Network Nodes as required and the Tru-Site Computers
- B. The three (3) year period starts on date of final acceptance of the completed system by the Owner.

### PART 2 - PRODUCTS

#### 2.01 FIRE ALARM CONTROL PANEL (FACP)

- A. General: Comply with UL 864, "Control Units for Fire-Protective Signaling Systems."
- B. The following FACP hardware shall be provided:
  - 1. Power Limited base panel with beige cabinet and door, 120 VAC input power.
  - 2. 2,000 point capacity where (1) point equals (1) monitor (input) or (1) control (output).
  - 3. 2,000 points of Network Annunciation at FACP Display when applied as a Network Node
  - 4. 2,000 points of annunciation where one (1) point of annunciation equals:
    - a. 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module.
    - b. 1 LED on panel or 1 switch on panel.
  - 5. From all battery charging circuits in the system provide battery voltage and ammeter readouts on the FCP LCD Display.
  - 6. One Auxiliary electronically resettable fused 2A @24VDC Output, with programmable disconnect operation for 4-wire detector reset.
  - 7. One Auxiliary Relay, SPDT 2A @32VDC, programmable as a trouble relay, either as normally energized or de-energized, or as an auxiliary control.
  - 8. Where required provide Intelligent Remote Battery Charger for charging up to 110Ah batteries.
  - 9. Power Supplies with integral intelligent Notification Appliance Circuit Class B for system expansion.

10. Four (4) form "C" Auxiliary Relay Circuits (Form C contacts rated 2A @ 24VDC, resistive), operation is programmable for trouble, alarm, supervisory of other fire response functions. Relays shall be capable of switching up to ½ A @ 120VAC, inductive.
  11. The FACP shall support (6) RS-232-C ports and one service port.
  12. Remote Unit Interface: supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.
  13. Programmable DACT for either Common Event Reporting or per Point Reporting.
  14. Service Port Modem for dial in passcode access to all fire control panel information.
  - C. Cabinet: Lockable steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provide exactly matching modular unit enclosures.
  - D. Alphanumeric Display and System Controls: Panel shall include an 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.
  - E. Voice Alarm: Provide an emergency communication system, integral with the FACP, including voice alarm system components, microphones, amplifiers, and tone generators. Features include:
    1. Amplifiers comply with UL 1711, "Amplifiers for Fire Protective Signaling Systems." Amplifiers shall provide an onboard local mode temporal coded horn tone as a default backup tone. Test switches on the amplifier shall be provided to test and observe amplifier backup switchover. Each amplifier shall communicate to the host panel amplifier and NAC circuit voltage and current levels for display on the user interface.
    2. All announcements are made over dedicated, supervised communication lines. All risers shall support Class B wiring for each audio channel.
    3. Emergency voice communication audio controller module shall provide up to 32 minutes of message memory for digitally stored messages. Provide supervised connections for master microphone and up to 5 remote microphones.
    4. Status annunciator indicating the status of the various voice alarm speaker zones and the status of fire fighter telephone two-way communication zones.
  - F. Distributed Module Operation: FACP shall be capable of allowing remote location of the following modules; interface of such modules shall be through a Style 7 (Class A) supervised serial communications channel (SLC):
    1. Amplifiers, voice and telephone control circuits
    2. Addressable Signaling Line Circuits
    3. Initiating Device Circuits
    4. Notification Appliance Circuits
    5. Auxiliary Control Circuits
    6. Graphic Annunciator LED/Switch Control Modules
- 2.02 EMERGENCY POWER SUPPLY
- A. General: Components include battery, charger, and an automatic transfer switch.
  - B. Battery: Sealed lead-acid. Provide sufficient capacity to operate the complete alarm system in normal or supervisory (non-alarm) mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all

components of the system, including all alarm indicating devices in alarm or supervisory mode for a period of 15 minutes.

## 2.03 ADDRESSABLE MANUAL PULL STATIONS

- A. Description: Addressable single- or double-action type, red LEXAN, with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.
- B. Protective Shield: Where required provide a tamperproof, clear LEXAN shield and red frame that easily fits over manual pull stations. When shield is lifted to gain access to the station, a battery powered piercing warning horn shall be activated. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.

## 2.04 SMOKE SENSORS

- A. General: Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:
  - 1. Factory Nameplate: Serial number and type identification.
  - 2. Operating Voltage: 24 VDC, nominal.
  - 3. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.
  - 4. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.
  - 5. Each sensor base shall contain an LED that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the sensor base LED shall be on steady.
  - 6. Each sensor base shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
  - 7. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
  - 8. The sensor's electronics shall be immune from false alarms caused by EMI and RFI.
  - 9. Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP. Sensor address shall be located in base to eliminate false addressing when replacing sensors.
  - 10. Removal of the sensor head for cleaning shall not require the setting of addresses.
- B. Type: Smoke sensors shall be of the photoelectric or combination photoelectric / heat type.
- C. Bases: Relay output, sounder and isolator bases shall be supported alternatives to the standard base.
- D. Duct Smoke Sensor:
  - 1. Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Sensor

includes relay as required for fan shutdown.

2. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct sensor shall be provided by the FACP.
3. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable. Relay shall be mounted within 3 feet of HVAC control circuit.
4. Duct Housing shall provide a relay control trouble indicator Yellow LED.
5. Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
6. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.
7. Duct Housing shall provide a magnetic test area and Red sensor status LED.
8. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
9. Each duct sensor shall have a Remote Test Station with an alarm LED and test switch.

## 2.05 HEAT SENSORS

- A. Thermal Sensor: Combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; 135-deg F fixed-temperature setting except as indicated.
- B. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag.
- C. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACP for either 15-deg F or 20-deg F per minute.
- D. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

## 2.06 ADDRESSABLE CIRCUIT INTERFACE MODULES

- A. Addressable Circuit Interface Modules: Arrange to monitor one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of evacuation indicating appliances and AHU systems.
- B. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line or a separate two wire pair running from an appropriate power supply as required.
- C. There shall be the following types of modules:
  1. Type 1: Monitor Circuit Interface Module:
    - a. For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
    - b. For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.

2. Type 2: Line Powered Monitor Circuit Interface Module

- a. This type of module is an individually addressable module that has both its power and its communications supplied by the two wire multiplexing signaling line circuit. It provides location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall have the capability of communicating four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
- b. This module shall provide location specific addressability for up to five initiating devices by monitoring normally closed or normally open dry contact security devices. The module shall communicate four zone status conditions (open, normal, abnormal, and short). The two-wire signaling line circuit shall supply power and communications to the module.

3. Type 3: Single Address Multi-Point Interface Modules

- a. This multipoint module shall provide location specific addressability for four initiating circuits and control two output relays from a single address. Inputs shall provide supervised monitoring of normally open, dry contacts and be capable of communicating four zone status conditions (normal, open, current limited, and short). The input circuits and output relay operation shall be controlled independently and disabled separately.
- b. This dual point module shall provide a supervised multi-state input and a relay output, using a single address. The input shall provide supervised monitoring of two normally open, dry contacts with a single point and be capable of communicating four zone status conditions (normal, open, current limited, and short). The two-wire signaling line circuit shall supply power and communications to the module.
- c. This dual point module shall monitor an unsupervised normally open, dry contact with one point and control an output relay with the other point, using a single address. The two-wire signaling line circuit shall supply power and communications to the module.

4. Type 4: Line Powered Control Circuit Interface Module

5. This module shall provide control and status tracking of a Form "C" contact. The two-wire signaling line circuit shall supply power and communications to the module.

6. Type 5: 4-20 mA Analog Monitor Circuit Interface Module

- a. This module shall communicate the status of a compatible 4-20 mA sensor to the FACP. The FACP shall annunciate up to three threshold levels, each with custom action message; display and archive actual sensor analog levels; and permit sensor calibration date recording.
- D. All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

2.07 MAGNETIC DOOR HOLDERS

- A. Description: Units shall be listed to UL 228. Units are equipped for wall or floor mounting as indicated and are complete with matching door plate. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source, and develops a minimum of 25 lbs. holding force.
- B. Material and Finish: Match door hardware.

2.08 STANDARD ALARM NOTIFICATION APPLIANCES

- A. Alarm notification appliances by Simples Grinnell and COOPER Notification (Wheelock) are  
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acceptable.

- B. Visible/Only: Strobe shall be listed to UL 1971. The V/O shall consist of a xenon flash tube and associated lens/reflector system. The V/O enclosure shall mount directly to standard single gang, double gang or 4" square electrical box, without the use of special adapters or trim rings. V/O appliances shall be provided with different minimum flash intensities of 15cd, 75cd and 110cd. Provide a label inside the strobe lens to indicate the listed candela rating of the specific Visible/Only appliance.
- C. Speaker/Visible: Combination Speaker/Visible (S/V) units combine the speaker and visible functions into a common housing. The S/V shall be listed to UL 1971 and UL 1480.
  - 1. Twisted/shielded wire is required for speaker connections on a standard 25VRMS or 70.7VRMS NAC using and UTP conductors, having a minimum of 3 twists per foot is required for addressable strobe connections.
  - 2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.
  - 3. The S/V shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.
  - 4. The S/V installs directly to a 4" square, 1 ½ in. deep electrical box with 1 1/2" extension for Simplex devices and a 4" square 1 ½ in. deep for Wheelock devices.
- D. Speaker: Speaker notification appliances shall be listed to UL 1480.
  - 1. The speaker shall operate on a standard 25VRMS or 70.7VRMS NAC using twisted / shielded wire.
  - 2. The following taps are available: 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker has minimum UL rated sound pressure level of 84dBA at 10 feet.
  - 3. The S/V shall have a frequency response of 400 to 4000 Hz for Fire Alarm and 125 to 12kHz for General Signaling.
  - 4. The Speaker installs directly to a 4" square, 1 ½ in. deep electrical box with 1 1/2" extension for Simplex devices and a 4" square 1 ½ in. deep for Wheelock devices.
- E. Notification Appliance Circuit provides synchronization of strobes at a rate of 1Hz. The capability to synchronize multiple notification appliance circuits shall be provided.
- F. Accessories: The contractor shall furnish the necessary accessories.
- G. NAC Power Extender
  - 1. The IDNet NAC Power Extender panel shall be a stand-alone panel capable of powering a minimum of 4 notification appliance circuits. Notification appliance circuits shall be [Class B Style Y][Class A Style Z] rated at 2 amps each. Panel shall provide capability to be expanded to 8 notification appliance circuits.
  - 2. The internal power supply & battery charger shall be capable of charging up 12.7 Ah batteries internally mounted or 18Ah batteries mounted in an external cabinet.
  - 3. The NAC extender panel may be mounted close to the host control panel or can be remotely located. The IDNET Addressable NAC Extender Panel when connected to an addressable panel shall connect to the host panel via an IDNet communications channel. Via the IDNET channel each output NAC can be individually controlled for general alarm or selective area notification.
  - 4. For IDNet connected NAC extender panels up to five panels can be connected on a single [Class A wired] IDNet channel.
  - 5. When connected to a conventional (non-addressable panel) one or two standard

notification appliance circuits from the main control panel may be used to activate all the circuits on the NAC power extender panel.

6. Alarms from the host fire panel shall signal the NAC power extender panel to activate. The panel shall monitor itself and each of its NACs for trouble conditions and shall report trouble conditions to the host panel.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION, GENERAL

- A. Install system components and all associated devices in accordance with applicable NFPA Standards and manufacturer's recommendations.
- B. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:
  1. Factory trained and certified personnel.
  2. National Institute of Certification in Engineering Technologies (NICET) fire alarm level II certified personnel.
  3. Personnel licensed or certified by state or local authority.

#### 3.02 WIRING INSTALLATION

- A. System Wiring: Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the Authority Having Jurisdiction (AH) and shall be installed in accordance with the appropriate articles from the current approved edition of NFPA 70: National Electric Code (NEC).
- B. Contractor shall obtain from the Fire Alarm System Manufacturer written instruction regarding the appropriate wire/cable to be used for this installation. No deviation from the written instruction shall be made by the Contractor without the prior written approval of the Fire Alarm System Manufacturer.
- C. Paint fire alarm system junction boxes covers red.

#### 3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.
- B. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
  1. Factory trained and certified.
  2. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
  3. International Municipal Signal Association (IMSA) fire alarm certified.
  4. Certified by a state or local authority.
  5. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.
- C. Pre-testing: Determine, through pre-testing, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
- D. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for  
FIRE ALARM ADDRESSABLE WITH ADDRESSABLE SPEAKER - VISUAL

final acceptance testing.

- E. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.
- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.
- H. Final Test, Certificate of Completion, and Certificate of Occupancy:
- I. Test the system as required by the Authority Having Jurisdiction in order to obtain a certificate of occupancy.

### 3.04 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Clean unit internally using methods and materials recommended by manufacturer.
- B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls and sensitivities to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

### 3.05 TRAINING

- A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.
- B. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 8 hours' training.
- C. Schedule training with the Owner at least seven days in advance.

### 3.06 SPECIAL INSTALLATION INSTRUCTIONS

- A. Provide a Voice Command Center (VCC) at main entry for fire department interface and remote annunciation. See drawings for location.
- B. The existing fire alarm devices are wired to the existing basement Gillum Hall FACP. This project will remove that interface and provide a standalone system for Dreiser Hall, connected to the Campus fire alarm network.
- C. Provide interface with existing stage rooftop exhaust fans, to run fans during any alarm in the Theater area, utilizing existing motor starters located stage left.
- D. Provide interface with Theater lighting control system to turn lights on to 100% during any alarm in the Theater area.
- E. Provide interface with the Theater sound system to silent the sound system during any alarm in the Theater area (while fire alarm A/V's are sounding).
- F. Provide interfaces for elevator recall, HVAC fan shutdown and emergency notification, per drawings.
- G. See drawings for any additional requirements.

END OF SECTION 283111.10

## PART 1 - GENERAL

### 1.1 METERING REQUIREMENTS

- A. All new buildings and buildings with major mechanical and electrical renovations shall be metered. ISU Facilities Management shall be contacted to review requirements.
- B. Meters to be installed include:
  - 1. Steam condensate .
  - 2. Chilled water.
  - 3. Electricity.
- C. In buildings where steam is routed throughout the building, or steam is used for cleaning or humidification purposes and is estimated at more than 5% of annual usage, then a steam flow meter will be required. Consult ISU Facilities Management in these instances to confirm.
- D. All meters shall be connected to and monitored by the Campus Building Automation System. All data shall be recorded, tabulated and automatically e-mailed as noted here-in.

## PART 2 - PRODUCTS

### 2.1 STEAM CONDENSATE METERS

- A. Condensate meters shall be vortex shedding meters installed downstream of condensate pump and designed for maximum flow rate of condensate pump.
  - 1. ANSI 125 lb. flanged end connections.
  - 2. Maximum temperature of 250 degrees Fahrenheit.
  - 3. Each transmitter shall be NIST certified, shall have HART protocol communication, and shall have an output 4-20 mA processing signal. Input power shall be 24VDC.
  - 4. The Accuracy of the meters shall be  $\pm 1.5\%$  over the actual flow range and repeatability of 0.25%. Meters will be factory calibrated and tagged with calibration information attached to meter.
  - 5. All meters are to be factory calibrated and be shipped with calibration certifications.
  - 6. Meter shall be shipped with Instrument Society of America (ISA) Data Sheet, filled out to completeness and representative of the meter being shipped.
- B. Approved Manufacturer
  - 1. Endress + Hauser: Pro Wirl 72F.

### 2.2 CHILLED WATER METERING

- A. Meter

1. Chilled water meters shall be in-line electromagnetic installed in the chilled water return piping.
2. In-line Electromagnetic Flow Meters.
  - a. The flow meter shall be complete with remote transmitter that has a backlit graphic display and keypad. Each flow meter shall be factory sized, factory programmed, and factory calibrated/certified for its specific application.
  - b. Connections to the piping shall be ANSI class 150 flanges. Provide suitable mating flanges and reducer/expander as required. Typically the meters are smaller than the pipe size.
  - c. Meter shall be capable of operating conditions of 40-degF water temperature and 150-psig pressure.
  - d. The flow tube shall be epoxy coated steel; the sensing electrodes shall be SS, button type; the liner shall be polypropylene.
  - e. The magnetic flow meter shall be microprocessor based with integral electronics. The electronics shall be interchangeable for all sizes of meters from 1/2 inch to 24 inch. Electronics shall be removable while flow tube stays in operation and can be sent to factory for repair and re-calibration. Electronics housing shall be powder-coated cast aluminum with a NEMA4X rating.
  - f. Each flow meter shall be individually wet-calibrated and accurate to within  $\pm 0.5\%$  of reading from 3 to 33 fps velocity. A certificate of calibration shall be provided with each flow meter. Each meter shall also be accompanied by a fully executed ISA Data Sheet with all the details of the meter.
  - g. The meter shall incorporate a high impedance amplifier of  $10^{12}$  ohms or greater to eliminate need for electrode cleaning systems. The meter shall use bipolar pulsed DC coil excitation with auto-integrated zeroing each half-cycle. Power consumption shall be no more than 12VA, independent of meter size. Input power shall be 11-40 VDC.
  - h. The meter's analog and pulse output signals shall be isolated 4-20 mA (700-ohm load) and scalable pulse from 0-1000Hz. Full scale value shall be adjustable. The open collector shall be capable of serving as status output indicating either system or process error, or flow direction. A low flow cutoff will be standard, which can be turned on or off via push buttons on the electronics module. A LCD display shall indicate flow rate. The totalizer value shall be protected by EEPROM during power outages and utilize an overflow counter. The display shall also be capable of indicating error messages such as empty pipe, error condition and low flow cutoff. The flow meter shall have the capability of being programmed remotely using HART protocol.
  - i. If the meter is installed in PVC pipe, an internal grounding electrode shall be provided which eliminates the need for external grounding rings.
  - j. Meter shall have capability of connecting to vendor verification and diagnostic equipment to perform field checks of meter and transmitter operability and certification that meter is still within factory settings.
3. Approved manufacturer
  - a. Endress + Hauser: Proline Promag 50 W.

B. Chilled Water Temperature Sensors

1. Chilled water supply and return temperature sensors, shall be used to calculate BTU's. These sensors will be part of the temperature control building automation system.

## 2.3 ELECTRICAL METERING

Electrical metering shall be from an interface with electrical switch gear metering. Metering for electrical gear will be provided as part of this project. Confirm the electrical gear meter type for compatibility with the control system.

## PART 3 - INSTALLATION

### 3.1 METER INSTALLATION

- A. All meters shall be installed with a definitive means of service and removal to exterior of building.
- B. All meters will require at least 18" service clearance above, below and on one side.
- C. Meters must be supported independent from the piping system.
- D. Meters must be installed with the manufacturers recommended straight run of pipe, both upstream and downstream.

### 3.2 UTILITY USAGE

- A. All usage shall be automatically uploaded to the existing campus building automation system. The usage shall be indicated in appropriate units, (i.e. Ton-Hrs, KWH's, PPH, etc.) and be input on one simple to read EXCEL spread sheet. The existing spread sheet that has been developed for this purpose, shall be used. Building SF shall be included on spread sheet. Year to date energy usage and annual energy usage in BTU/SF shall be totaled in the far right columns.
- B. This cumulated energy data will be used to determine the pro-rata energy use of each metered building when compared to the whole campus energy use (buildings are served by central systems and one electrical service). Metering will also be used to gauge energy efficiency of each individual building on a BTU/SF basis.
- C. The energy usage meter system shall be an extension of the existing Johnson Controls Campus Building automation system. The existing head end application data server located in the Facilities Management Office shall be used.

END OF SECTION 330900

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