

University of Colorado VISUAL ARTS COMPLEX

Boulder, Colorado 80309

METAL SHOP VENTILATION RETROFIT

PROJECT MANUAL
(Divisions 1, 9, 15 & 16)

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CU VISUAL ARTS COMPLEX
University of Colorado in Boulder
Boulder, Colorado
METAL SHOP VENTILATION RETROFIT
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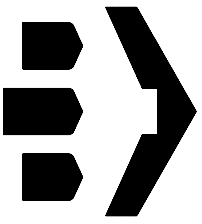
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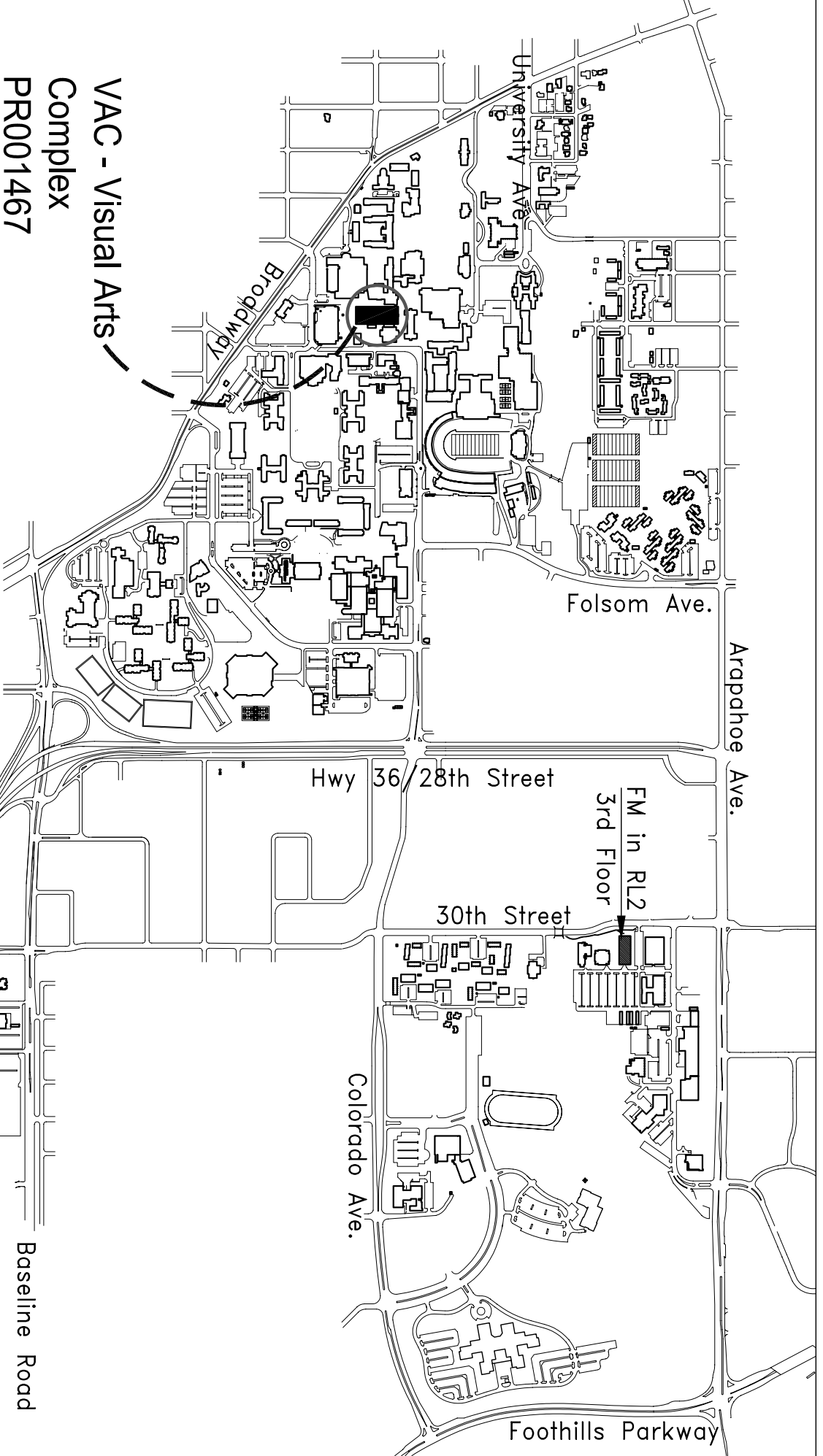
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VAC - Visual Arts
Complex
PR001467



1.01 CONDITIONS AND REQUIREMENTS

Division 1 - General Requirements shall govern work under all Divisions of the Specifications.

1.02 SPECIFICATION LANGUAGE EXPLANATION

Specifications are of abbreviated, simplified or streamlined type and include incomplete sentences. Omissions of words or phrases such as "the Contractor shall," "in conformity therewith," "shall be," "as noted on the Drawings," "a," "the" are intentional. Supply omitted words or phrases by inference in same manner as they are when "NOTE" occurs on Drawings. Supply words "shall be" or "shall" by inference when colon is used within sentences or phrases. Supply words "on the Drawings" by inference when "as indicated" is used with sentences or phrases.

Where reference is made to specifications, societies, institutes, or associations or manufacturer's directions, they are, except as may be inconsistent herewith, made part of specifications, to same extent as if written out in full herein. Use latest edition, at time of bidding, if a date is not given.

1.03 ABBREVIATIONS

References in Contract Documents to trade associations, technical societies, recognized authorities and other institutions include following organizations, which are sometimes referred to only by corresponding abbreviations:

AA	Aluminum Association
AAMA	Architectural Aluminum Manufacturer's Association
ACI	American Concrete Institute
AIMA	Acoustical and Insulating Materials Association (successor to AMA and IBI)
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
AMA	Acoustical Materials Association
ANSI	American National Standards Institute (successor to USASI and ASA)
APA	American Plywood Association
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWS	American Welding Society
CDA	Copper Development Associations, Inc.
CM/GC	Construction Manager/General Contractor
CRA	California Redwood Association
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standard (U.S. Department of Commerce)
DFPA	Douglas Fir Plywood Association
EPA	Environmental Protection Agency
FGMA	Flat Glass Marketing Association
FIA	Factory Insurance Association
FM	Factory Mutual Engineering Division
FS	Federal Specification
MIA	Marble Institute of America

MIL	Military Specification
MILMA	Metal Lath Manufacturer's Association
NAAMM	The National Association of Architectural Metal Manufacturers
NBFU	National Board of Fire Underwriters
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NEC	National Electric Code (of NBFU)
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NMWIA	National Mineral Wool Insulation Association
NPVLMMA	National Paint, Varnish and Lacquer Manufacturers' Association
NTMA	The National Terrazzo and Mosaic Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PEI	Porcelain Enamel Institute
PS	Product Standard (U.S. Department of Commerce)
SCPI	Structural Clay Products Institute
SDI	Steel Deck Institute
SJI	Steel Joist Institute
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
SPA	Southern Pine Association
SPI	The Society of Plastic Industry, Inc.
SPR	Simplified Practice Recommendation (U.S. Department of Commerce)
SSPC	Steel Structures Painting Council
SWI	Steel Window Institute
TCA	Tile Council of America
UL	Underwriters' Laboratories, Inc.
WCLA	West Coast Lumbermen's Association
WRI	Wire Reinforcement Institute
WWPA	Western Wood Products Association

1.04 LAYING OUT WORK

The Contractor will furnish reference bench mark and maintain bench mark and all other grades, lines, and levels and dimensions as indicated in the Contract Documents. Report any errors or inconsistencies in above to Owner before commencing work.

Except as delegated by subcontract or normal trade practice, the Contractor will be responsible for all lines, elevations, and measurements of work indicated.

1.05 EXAMINATION OF SITE

Failure to visit the site will in no way relieve any Contractor from the necessity of furnishing materials or performing work that may be required to complete work in accordance with the Contract Documents without additional cost to Owner.

END OF SECTION

PART 1 - GENERAL

1.01 SCHEDULE OF DRAWINGS, SPECIFICATIONS AND ADDENDA

The following Drawings, Project Manual, and Addenda from the Contract Documents.

A. Set(s) of Drawings & project manuals dated July 06, 2010. Drawing list is as follows:

Sheet No. / Titled

T1.00 TITLE PAGE

ARCHITECTURAL

A11.1.2A LEVEL 2 INT. FINISH PLAN - AREA A

MECHANICAL

M0.0 SYMBOLS AND ABBREVIATIONS
MD2.2A LEVEL 2 DEMO DUCTWORK - AREA A
MD3.2A LEVEL 2 DEMO PIPING - AREA A
M2.2A LEVEL 2 DUCTWORK - AREA A
M2.4A LEVEL 4 DUCTWORK - AREA A
M2.4B LEVEL 4 DUCTWORK - AREA B
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M7.1 METAL SMITHING RM 290A - FLOW DIAGRAM
M7.2 METAL SMITHING RM 290 - FLOW DIAGRAM
M8.0 MECHANICAL DETAILS
M9.0 MECHANICAL DETAILS

ELECTRICAL

E0.0 SYMBOLS & ABBREVIATIONS
E3.2A LEVEL 2 POWER- AREA A
E3.4A LEVEL 4 POWER- AREA A
E3.5A ROOF POWER- AREA A
E9.0 ELECTRICAL SCHEDULES

SECTION 09000 – INTERIOR FINISHES AND SPECIFICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Refer to sheets following this section.

- B. Related Sections include the following:
 - 1. Division 1 Section: "Sustainable Requirements" for additional sustainable green building requirements.
 - 2. Division 1 Section: "Construction Waste Management and Recycling." for additional waste and recycling requirements.

1.2 SUBMITTALS

- A. LEED Submittals:
 - 1. Local/Regional Materials: Provide a statement from the manufacturer stating that materials provided were manufactured within a 500 mile radius of the project. Include location of the manufacturing facility including name, address and distance between manufacturing facility and the project site. Provide manufacturer's documentation indicating location where the base materials were extracted, mined, harvested, etc. and distance between manufacturing facility and the project site (Applies to LEED MRc5.1 and MRc5.2: Regional Materials).
 - a. Include material costs (excluding cost of installation).
 - 2. Recycled Content: Provide a statement from the manufacturer including the recycled content percentage, by weight, and whether the recycled content is post-consumer or post-industrial (Applies to LEED MRc4.1 and MRc4.2: Recycled Content).
 - 3. Credit EQ 4.1: Manufacturers' product data and material safety data sheets (MSDS) for construction adhesive and sealants used on the interior of the building, including printed statement of VOC content in g/L.
 - 4. Credit EQ 4.2: Manufacturers' product data and material safety data sheets (MSDS) for construction painting and coatings used on the interior of the building, including printed statement of VOC content in g/L.
 - 5. Credit EQ 4.3: Manufacturers' product data for carpet products used on the interior of the building indicating that the product meets the Carpet and Rug Institute's "Green Label Plus" program and the carpet cushion meets the requirements of the Carpet and Rug Institute's "Green Label Plus" program
 - 6. Credit EQ 4.4: Composite wood manufacturer's product data for each composite wood product used indicating that bonding agent used contains no urea formaldehyde.
 - 7. Credit MR 7: Certificates of chain-of-custody signed by manufacturers certifying that products specified to be made from certified wood were made from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC 1.2, "Principles and Criteria." Include evidence that mill is certified for chain-of-custody by an FSC-accredited certification body (Applies to LEED MRc5.7: Certified Wood).

- a. Include cost of material and chain-of-custody certification number obtained from manufacturer.

PART 2 – PRODUCTS

2.1 MATERIALS, GENERAL

A. LEED Requirements:

1. Recycled Content: Provide indication that materials/products contain the maximum amount of recycled content permitted in order for material or product to retain its integrity.
2. Local/Regional Materials: Preference shall be given to products and materials which have been manufactured, harvested, extracted mined quarried, etc. within a 500 mile radius of the project site.
3. VOC Content EQc 4.1: Adhesives and sealants used on the interior of the building shall comply with VOC limits indicated in Division 1 Section – “Sustainable Requirements.”
4. VOC Content EQc 4.2: Paintings and coatings used on the interior of the building shall comply with VOC limits indicated in Division 1 Section – “Sustainable Requirements.”
5. VOC Content EQc 4.3: Carpet and carpet products used on the interior of the building shall comply with VOC limits indicated in Division 1 Section – “Sustainable Requirements.”
6. Certified Woods: Wood based products shall be made from wood obtained from forests certified by an FSC accredited certification body to comply with the Forest Stewardship Councils “Principles and Criteria.”

PART 3 – EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT AND RECYCLING

- A. All project construction waste and recycled materials shall be managed in accordance with Division 1 Section 01690 – “Construction Waste Management and Recycling.” The Contractor shall submit documentation satisfying the requirements of that section.

END OF SECTION 09000

SECTION 15050 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.02 DESCRIPTION

- A. Intent of Drawings and Specifications is to obtain complete systems, tested, adjusted, and ready for operation.
- B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 15 Contract Documents shall have the following meanings:
 - 1. "Provide" or "provided" shall mean "furnish and install".
 - 2. "Furnish" or "furnished" does not include installation.
 - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate Work with Drawings and Specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
- F. Where Architectural features govern location of Work, refer to existing conditions.
- G. Contractor may install additional piping, fittings and valves, not shown on drawings, for testing purposes or for convenience of installation. Where such materials are installed, they shall comply with Specifications and shall be sized to be compatible with system design. Remove such installed materials when they interfere with design conditions or as directed by Architect.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

- A. Rules and regulations of Federal, State and Local authorities and utility companies, in force at time of execution of Contract shall become part of this Specification.

1.04 REFERENCE STANDARDS

- A. Agencies or publications referenced herein refer to the following:
 - 1. AGAAmerican Gas Association
 - 2. AHJAuthority Having Jurisdiction which is FLS
 - 3. AMCAAir Movement and Control Association
 - 4. ANSIAmerican National Standards Institute
 - 5. ARIAir-Conditioning and Refrigeration Institute
 - 6. ASHRAEAmerican Society of Heating Refrigerating and Air Conditioning Engineers
 - 7. ASPEAmerican Society of Plumbing Engineers

8. ASSEAmerican Society of Sanitary Engineering
9. AWSAmerican Welding Society
10. AWWAAmerican Water Works Association
11. ASMEAmerican Society of Mechanical Engineers
12. ASTMAmerican Society for Testing and Materials
13. CDHColorado Department of Health
14. CISPICast Iron Soil Pipe Institute
15. FLSFire and Life-Safety Group (Univ. of Colorado at Boulder)
16. FMGFM Global
17. F.M.Department of Facilities Management
18. FSFederal Specifications
19. IBCInternational Building Code
20. IEEEInstitute of Electrical and Electronics Engineers
21. IFCInternational Fire Code
22. MCAMechanical Contractors Association
23. MSSManufacturers Standardization Society
24. NECNational Electrical Code
25. NEMANational Electrical Manufacturers Association
26. NICETNational Institute for Certification in Engineering Technologies
27. NFPANational Fire Protection Association
28. NISTNational Institute of Standards & Technology
29. NSFNational Sanitation Foundation
30. OWNERUniversity of Colorado at Boulder
31. PDIPlumbing and Drainage Institute
32. SMACNASheet Metal and Air Conditioning Contractors National Association
33. ULUnderwriters Laboratories, Inc.
34. WCFWater Conditioning Foundation

1.05 SUBMITTALS

A. Shop Drawings (Product Data):

1. Refer to Section 01300 - Submittals, Shop Drawings, Product Data and Samples.
2. Note that for satisfying submittal requirements for Division 15, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Section 01300. However, the expression "Shop Drawings" is generally used throughout Specification.
3. Submit Shop Drawings for equipment and systems as requested in the respective specification sections. Submittals that are not requested may not be reviewed.
4. Mark general catalog sheets and drawings to indicate specific items submitted.
5. Include proper identification of equipment by name and/or number, as indicated in Specification and shown on drawings.
6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference numbers for each item. Submittals shall be clearly marked and noted accordingly.
7. When fixtures, equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include all required components.

8. Submittals of electrically powered equipment and devices shall include composite wiring diagrams, motor efficiency and power factor data.
 9. Submit equipment room layouts drawn to scale, including equipment, piping, accessories and clearance for maintenance.
 10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
 11. Submit Shop Drawings or product data as soon as practicable after signing Contracts. Submittals must be approved before installation of materials and equipment.
 12. Submittals that are not complete, not permanent or not properly checked by Contractor will be returned without review.
 13. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 15 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork or electrical raceway layouts.
 14. Unless specifically requested in Division 15 Technical Sections, submittals of coordination drawings will be returned without review.
- B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
- C. Operation and Maintenance Manuals:
1. Refer to Section 01700 – Contract Closeout.
 2. Upon completion of Work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit all 3 copies to Owner.
 3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
 4. Fire protection system shall be separately bound and include a current copy of NFPA-25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.
 5. Manuals shall include the following:
 - a. Copies of all Shop Drawings
 - b. Manufacturer's operating and maintenance instructions. Include parts lists of all items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
 - c. CD ROM's of O&M data with exploded parts lists, where available.
 - d. Phone numbers and addresses of local parts suppliers and service companies.
 - e. Internet/WEB page addresses where applicable.
 - f. Wiring diagrams.
 - g. Startup and shutdown procedures.
 - h. Composite electrical diagrams.
 - i. Flow diagrams.
 - j. Lubrication instructions.
 - k. Factory and field test records. (Refer to Test and Balancing in Part 3 of this Section.)
 - l. Air and water balance reports.
 - m. Valve identification charts as specified in Section 15190 - Mechanical System Identification.

- n. Access panel identification charts as specified in Section 15190 - Mechanical System Identification.
 - o. Additional information, diagrams or explanations as designated under respective equipment or systems specification sections.
- 6. Instruct Owner's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
 - 7. Provide O&M manuals and instructions to Owner prior to request for final payment.
- D. Record Documents:
- 1. Refer to General Conditions of Contract, and Section 01700 – Contract Closeout. Prepare complete set of Record Drawings in accordance with Section 01700.
 - 2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.06 JOB CONDITIONS

- A. Building Access:
- 1. Arrange for necessary openings in building to allow for admittance of all apparatus.
- B. Electrical Coordination:
- 1. Refer to Section 15055 - Motors.
 - 2. This Contractor shall provide the following items as specified under Division 15:
 - a. Motors
 - b. Electrically powered equipment
 - c. Electrically controlled equipment
 - d. Starters, where specified
 - e. Variable frequency drives, where specified.
 - f. Control devices, where specified
 - g. Temperature Control wiring
 - h. Wiring diagrams to Electrical Contractor for apparatus indicating external connection and internal controls.
 - 3. Electrical Contractor will provide the following devices required for control of motors or electrical equipment, unless noted otherwise.
 - a. Starters
 - b. Disconnect devices
 - c. Control devices:
 - 1). Pushbuttons
 - 2). Pilot lights
 - 3). Contacts
 - d. Conduit, boxes and wiring for power wiring
 - e. Conduit, boxes and wiring for control wiring, except temperature control wiring
 - 4. Electrical Contractor will make connections, from power source to starter or variable frequency drive and from starter or variable frequency drive, where specified, to motor for ready to operate.
 - 5. Where starters or other similar control devices are furnished by this Contractor, they shall be installed by this Contractor and wired by Electrical Contractor.
 - 6. Should any change in size, HP rating or means of control be made to any motor or other electrical equipment after Contracts are awarded, this Contractor shall immediately notify

Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this Contractor.

C. Cutting and Patching:

1. Refer to General Conditions of the Contract, and Section 01045 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore all work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide all materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

D. Housekeeping and Cleanup:

1. Refer to Section 01700 – Contract Closeout.
2. Periodically as Work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of Work, remove tools, scaffolding, broken and waste materials, etc., from site.

1.07 GUARANTEE

- A. Guarantee for one year after acceptance by Owner all equipment, materials, and workmanship to be free from defect.
- B. Guarantee that systems will operate without objectionable noise, vibration and uncontrolled expansion.
- C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
- D. In any case, wherein fulfilling requirements of any guarantee, if this Contractor disturbs any work guaranteed under another Contract, this Contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other Contract.

PART 2 - PRODUCTS

2.01 NOT USED

PART 3 - EXECUTION

3.01 GENERAL

- A. Verify elevations and measurements prior to installation of materials.

3.02 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc., with appropriate Contractors.
- B. Steel sleeves, when required in interior floor slabs, shall be Schedule 40 carbon steel pipe with integral water stop.

- C. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials (metal pipe, plastic pipe, conduit, etc.), sizes of each, opening sizes and sealant products intended for use.
- D. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 15084.
- E. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, all required openings, including those sleeved, formed or core drilled. Drawings shall be approved prior to preparing openings in structural member.
- F. Openings for insulated piping shall be sized based on outside diameter of insulation when it is specified or detailed to be continuous through opening.
- G. Openings for duct penetrations shall be no more than 1/2" larger on all sides than size of duct or duct including duct insulation, if applicable. Where firestopping systems are required at penetrations, size in accordance with recommendations of firestopping systems manufacturer, but opening shall not exceed one inch average clearance on all sides. Openings for ducts with fire dampers shall be in accordance with fire damper installation requirements.
- H. Duct penetrations through concrete floors in mechanical rooms containing liquid heat exchangers and/or pumps shall have 2" high water stopped curbs surrounding openings. This applies to mechanical rooms above the lowest floor level.
- I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embecco by Master Builders, or urethane caulk, as appropriate.
- J. Seal non fire-rated wall openings with urethane caulk.
- K. Finish and trim penetrations as shown on details and as specified.
- L. Provide chrome or nickel plated escutcheons where piping passes through walls, floors or ceilings and is exposed in finished areas. Size escutcheons to fit pipe and pipe covering for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.
- M. Trim duct penetrations exposed in finished areas with 2" wide galvanized or aluminum trim collars properly sized to fit duct. Collars shall be same gauge as duct, prime finish unless noted otherwise. Finished areas shall not include mechanical rooms, janitors' closets, storage rooms, etc., unless suspended ceilings are specified.

3.03 EQUIPMENT ACCESS

- A. Install piping, conduit and accessories to permit access to equipment for maintenance. Relocation of piping, equipment or accessories as required to provide access shall be provided at no additional cost to Owner.
- B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment without moving other equipment or system components being installed or already in place.
- C. Access doors in walls, chases, or inaccessible ceilings will be provided under Section 08305 - Access Doors, unless otherwise indicated. Access doors for valves, shock stops or other equipment shall provide access for service, repairs, and/or maintenance.

- D. Provide access doors where any valves, shock stops, unions or equipment/devices requiring access for servicing, repairs or maintenance are located in walls, chases or above inaccessible ceilings, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Access doors used in fire rated construction must have UL label. Access doors shall be steel, prime coated unless otherwise specified. Provide stainless steel doors in ceramic tile walls, toilet rooms, and locker rooms and in areas subject to excessive moisture. Access doors shall be of sufficient size to allow for total maintenance. Location of access doors shall be coordinated with General Contractor and location of equipment shall be roughed in accordingly.

3.04 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
- B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.
- C. Do not support equipment or piping from metal roof decking.

3.05 EQUIPMENT GUARDS

- A. Provide equipment guards over belt driven assemblies, pump shafts, exposed fans, and elsewhere as indicated in this specification or required by code.
- B. Paint equipment guards bright yellow.
- C. Equipment guards, shall comply with OSHA requirements.

3.06 SUPPORT PROTECTION

- A. In occupied areas, mechanical rooms and any areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment and mechanical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
- C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.07 MECHANICAL SYSTEMS IDENTIFICATION

- A. Refer to Section 15190 - Mechanical Systems Identification.

3.08 TEST AND BALANCING

- A. Tests for equipment, ductwork and piping systems shall be performed as specified in their respective specification sections.

3.09 START-UP

- A. All systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation. This shall include "Owner-furnished, Contractor-installed" (OFCI) as well as "Contractor-furnished, Contractor-installed" (CFCI) systems and equipment. Follow manufacturer's pre-start-up check-out, start-up, trouble shooting and adjustment procedures. Contractor shall provide services of technician/mechanic knowledgeable in start-up and check-out of types of systems and equipment

on project. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel. Coordinate start-up with all trades.

3.10 LUBRICATION

- A. Upon completion of Work and before turning over to Owner, clean and lubricate bearings except sealed and permanently lubricated bearings, and factory-lubricated equipment. Use only lubricant recommended by manufacturer.
- B. Contractor is responsible for maintaining lubrication of mechanical equipment under this Contract until Work is accepted by Owner.

3.11 CLEANING

- A. After installation is complete, clean all systems.
- B. Clean piping both internally and externally to remove dirt, plaster dust or other foreign materials. When external surfaces of piping are rusted, clean and restore surface to original condition.
- C. Clean pipeline strainers to restore them to original condition or replace with new strainer elements.
- D. Clean equipment and plumbing fixtures as recommended by manufacturers.
- E. Remove any tape or paper which was used to protect fire sprinklers from paint overspray.
- F. Replace throwaway or replaceable media air filters used during construction period with new filters or new filter media after construction has been completed and before building is turned over to Owner. Filter replacement shall be as hereinafter specified.
- G. Dirt, plaster dust and other foreign matter shall be vacuumed and cleaned from coils, terminal devices, diffusers, registers and grilles.
- H. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.
- I. Provide additional cleaning of individual piping systems and apparatus as hereinafter specified.

END OF SECTION 15050

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SECTION 15055 - MOTORS

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.02 SUBMITTALS

- A. Shop drawings including, but not limited to, the following:
 1. Manufacturer
 2. HP, voltage, phase, hertz, rpm
 3. Motor type
 4. Enclosure type
 5. Frame type
 6. Insulation class
 7. NEMA design designation
 8. Service factor
 9. Nominal efficiency at full load
 10. Power factor at full load
 11. Full load amperes
 12. Bearings
 13. Mountings
 14. Dimensions
 15. Weight

1.03 PRODUCT CRITERIA

- A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be listed by UL where applicable for service specified.
- B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
- C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
- D. Exposed motors (motors not protected by factory installed weather proof housings) located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.
- E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with a variable frequency drive.
 1. Refer to Section 15060 – Variable Frequency Drive (VFD) System.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Materials shall be new and guaranteed for service intended.

2.02 MOTORS

- A. Manufacturers: AO Smith, Baldor, General Electric, Could, Lincoln, Louis Allis, Reliance, Toshiba, Westinghouse.
- B. Voltage Ratings
 - 1. Refer to equipment schedules and specification sections for voltages required.
 - 2. Unless otherwise indicated, motors 1/3 HP and smaller shall be rated 115 volts for operation on 120 V, 1 phase, 60 Hz service.
 - 3. Unless otherwise indicated, motors 1/2 HP – 10 HP shall be rated:
 - a. 208 volts for operation on 208 V, 3 phase, 60 Hz service.
 - 4. Unless otherwise indicated, motors 15 HP and larger shall be rated:
 - a. 460 volts for operation on 480 V, 3 phase, 60 Hz service.
- C. Motors shall be 4-pole (approximately 1750 rpm) unless otherwise noted.
- D. Single-phase motors shall be furnished with built-in thermal overload protection.
- E. Use NEMA Design B motors, normal starting torque with regreasable ball bearings rated for minimum of 26280 hours L-10 life at full-load, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.
- F. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.
- G. Motors driven by variable frequency drives (VFD) shall comply with the latest NEMA MG-1, Section IV, and Part 31.
- H. Vibration shall not exceed 0.15 inch per second, unfiltered peak unless otherwise noted.
- I. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.
- J. Full load premium efficiency of motors 1 HP and larger, except special-purpose motors including 2-speed or multi-speed motors, inverter duty motors and rewind motors, shall meet or exceed listed values when tested in accordance with IEEE Standard 112 Method B as defined by NEMA Standard MG 1-12.6C. Efficiency values listed are based on NEMA Premier Efficiency Motors of NEMA MG. 1-1998, Table 12-12:

HP	<u>Open Motors</u>			<u>Enclosed Motors</u>		
	1200 rpm (6 pole)	1800 rpm (4 pole)	3600 rpm (2 pole)	1200 rpm (6 pole)	1800 rpm (4 pole)	3600 rpm (2 pole)
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5

HP	<u>Open Motors</u>			<u>Enclosed Motors</u>		
	1200 rpm (6 pole)	1800 rpm (4 pole)	3600 rpm (2 pole)	1200 rpm (6 pole)	1800 rpm (4 pole)	3600 rpm (2 pole)
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1

- K. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 HP and below may be shaded pole type.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install materials in accordance with drawings, approved shop drawings and manufacturer's recommendations.

END OF SECTION 15055

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SECTION 15060 - VARIABLE FREQUENCY DRIVE (VFD) SYSTEM

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15055 - Motors
- B. Section 15850 - Fans
- C. Section 15950 – Temperature Control System

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SYSTEM DESCRIPTION

- A. Provide variable frequency drives (VFD) for each pump, fan or other driven equipment sized to accommodate motors shown on drawings or schedules. All VFD's shall be from same manufacturer.
- B. VFD manufacturer shall review driven equipment and motors for VFD compatibility. Submit written statement from manufacturer of driven equipment along with VFD shop drawing submittals, indicating verification of compatibility.
- C. Contractor shall verify distance from motors to VFD's. VFD manufacturer shall provide sufficient equipment to assure proper operation and to avoid premature motor failure.
- D. VFD manufacturer shall provide filter equipment as necessary to limit voltage transient ring wave stress placed on stator windings to withstand rating value of motors supplied per Section 15055 - Motors.
- E. VFD shall vary speed of its respective fan, pump or other driven equipment motor in response to either 4-20 mA or 0-10 VDC control signal provided by Control Contractor.
- F. VFD system shall consist of the following:
 - 1. Variable frequency drive.
 - 2. UL listed disconnect device.
 - 3. Electrical noise attenuation device as required to meet electrical noise criteria.
 - 4. Motor starter for bypass mode operation with VFD/OFF/BYPASS selector and drive input and output isolation contactors where VFD bypass starters are specified.
 - 5. Line reactor.
 - 6. Step-up or step-down isolation transformer as required.

1.04 QUALIFICATIONS

- A. VFD system shall be furnished by, a manufacturer with at least 5 years experience in design, construction and application of VFD.

1.05 SUBMITTALS

- A. Shop drawings for each VFD system including, but not limited to, the following:
 - 1. Manufacturer's name.
 - 2. Identification of system components.
 - 3. Type of enclosure, front elevation and plan view, equipment weight, conduit access locations.
 - 4. Capacities/ratings.
 - 5. Warranty.
 - 6. System wiring and block diagram showing system components.
 - 7. Performance, control and protection data with specified features clearly shown.
 - 8. Operating and monitoring devices with specified features clearly indicated.
 - 9. Start-up operation, maintenance, spare parts, and field tests.
 - 10. Manufacturer's installation instructions.
 - 11. Other appropriate data.
 - 12. Variations from this Specification.
- B. After quality assurance tests are complete, submit written certification that drive and components have passed factory quality assurance tests.
- C. Submit calculations indicating conformance with electrical noise criteria specified. Refer to Electrical Documents for information regarding electrical building distribution system.
- D. Submit product and performance data on electrical noise attenuation device if required to meet electrical noise criteria specified. Isolation transformer is not electrical noise attenuation device.

1.06 ELECTRICAL NOISE CRITERIA

- A. Voltage and current distortion generated by VFD and attenuation devices measured at input and output of VFD assembly and as installed in place, shall not exceed the following criteria as referenced by IEEE Standard 519.
 - 1. Total harmonic distortion (THD) shall not exceed 3 % RMS of fundamental input voltage at full load with maximum 3% RMS on any single harmonic.
 - 2. Line voltage distortion shall not exceed 5% in amplitude of fundamental input voltage.
 - 3. Area of commutation notch (A_n) shall not exceed 16,400 voltmicroseconds measured at point of coupling to distribution system.
- B. VFD manufacturer shall perform harmonic analysis at input of distribution transformer to define submittals that compliance to IEEE-519-1992, General Category, is attained. Analysis shall include electrical one line drawing defining resistance and impedance of each wire run and transformer leading to each VFD. Analysis shall be computer generated and perform Fourier analysis of the system. Results shall list current and voltage amplitudes of all harmonics up to 50th level at input of distribution transformer. A summary shall detail percent total harmonic distortion for voltage and power factors for distortion displacement, and total.
- C. Electrical one line diagrams shown on Electrical Drawings include transformer kVA and impedance, and typical configuration of electrical system. Use this information for evaluation of harmonics for bidding purposes.
- D. Successful contractor must provide required data for VFD manufacturer to complete harmonic analysis. Information shall include utility short circuit amperes capability; distribution transformer kVA and impedance; length, size and number of wires per phase to motor control center feeding

VFD's; wire data to VFD's from motor control center; wire data to motor from VFD; and motor nameplate data.

- E. VFD manufacturer is responsible for cost of all equipment required to meet IEEE-519, General Category. Equipment, which can be provided, includes input line reactors, DC bus reactors and harmonic filters.

1.07 START-UP OPERATION AND MAINTENANCE DATA

- A. Manufacturer shall provide services of factory trained engineer or technician to approve installation; start-up test and adjust for proper operation; and instruct and train Owner's representative in operation and maintenance of VFD systems. Provide minimum of 4 hrs of Owner training for each VFD system.
- B. Should drive be deficient, drive manufacturer shall be required to make changes necessary to bring units into compliance with specified performance requirements. Cost of changes and retest shall be borne by drive manufacturer.
- C. Upon completion of this service, submit a report, signed by manufacturer's service representative, including start-up and test log.
- D. Manufacturer shall include additional 1 year (total 2 years) warranty for VFD system, covering parts, labor and travel expenses.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Manufacturers: ABB, Cutler-Hammer, Reliance/Rockwell Automation, Robicon, Mitsubishi or Toshiba.

2.02 FABRICATION

- A. VFD shall be variable torque, solid state, microprocessor based control, modular design for standard induction AC motor.
- B. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lock.
- C. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.
- D. Unit shall conform to NEMA and NEC standards and be CSA, UL or ETL listed. Control circuitry shall be electrically isolated from power circuitry. Entire assembly panel shall have UL or equivalent panel sticker.
- E. Inverter section shall be pulse width modulated (PWM) design and third generation insulated gate bipolar transistors (IGBTs).

2.03 PERFORMANCE REQUIREMENTS

- A. Input: 460 (+ 10%, - 5%) VAC, 3-phase, 60 (\pm 2) Hz.
- B. Output: 460 VAC, 3 phase, 10 to 60 Hz.
- C. Operating Environment Conditions: Ambient 0 to 40°C temperature, relative humidity up to 95% non-condensing.

- D. Linear acceleration and deceleration adjustable from 5 to 60 seconds. Provide adjustable v/Hz ratio and low speed boost features.
- E. Input harmonic distortion shall have true RMS (KW/RMSKVA) power factor greater than 90% at full load.
- F. Output Current Rating: Continuous full load output current rating of drive shall not be less than that listed for motor of equivalent horsepower in NEC table 430-150.
- G. Drive overload capacity to be minimum 110% of motor FLA based on NEC ratings for one minute.
- H. Time to Shutdown: Inversely proportional to square of overload current ($t = k/I^2$).
- I. Motor Regeneration Protection: Unit shall have capacity of dissipating regeneration energy without damage to or shutdown of drive. Unit shall be capable of starting into rotating load.
- J. Output Frequency Stability: $\pm 0.5\%$ of base frequency in 24 hrs throughout range of rated operating conditions.
- K. Output Voltage Regulation: $\pm 2\%$ of maximum rated output voltage.
- L. Output voltage rise time shall be no faster than 1000 volts/micro sec measured at the motor terminals. The voltage over shoot at the motor terminals shall be less than 250 volts.
- M. Power Loss Ride-Through: 3 cycles or 50 milliseconds.
- N. Linearity (speed reference to output frequency): $\pm 1.0\%$
- O. Input Power Factor: Minimum of 0.95 regardless of speed and load.
- P. Minimum drive efficiency as percent of input power shall be as follows:

Percent Load	Frequency (Hz)			
	<u>60</u>	<u>50</u>	<u>30</u>	<u>15</u>
100	97	96	95	90
75	97	96	94	90
50	97	96	94	90
25	96	95	91	84

2.04 CONTROL FEATURES

- A. VFD speed control circuit shall accept either 4-20 mA DC or 0-10 VDC isolated ungrounded transmitter signal in automatic mode and from manual speed potentiometer in manual mode.
- B. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 30%.
- C. Provide adjustable automatic reset for fault trips, except short circuit type faults. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selective.
- D. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.

- E. VFD shall be capable of starting into rotating loads spinning in any direction.
- F. Provide critical frequency avoidance circuit with at least 3 field adjustable bands to avoid operation at speeds, which cause excessive vibration in driven equipment.
- G. Provide isolated ungrounded output signal to indicate drive percent of speed or drive frequency.

2.05 COORDINATION WITH BUILDING AUTOMATION SYSTEM (BAS)

- A. Furnish each VFD with digital communication bus card for BAS use. Coordinate with Control Contractor for specific interface requirement.
- B. Provide contacts (1 NO and 1 NC contact) for remote control of start/stop function for VFD mode and second set for bypass mode if bypass is specified.
- C. Provide contacts (1 NO and 1 NC contact) for remote indication of VFD fault condition.

2.06 PROTECTION FEATURES

- A. Power circuits shall be protected by, electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.
 - 1. Instantaneous overcurrent and over voltage trip of output.
 - 2. Solid state protective circuit shall provide NEC motor running overload protection tested in accordance with UL Standard 991.
 - 3. Power line overvoltage or undervoltage.
 - 4. Phase sequence detection or insensitivity to incoming power phase sequence.
 - 5. Single and 3-phase short circuit protection.
 - 6. Control circuit malfunction.
 - 7. Overtemperature.
 - 8. Ground fault for all 3 phases.
- B. VFD shall protect itself from damage due to phase-to-phase or phase-to-ground faults without fuse blowing or use of isolation transformers. VFD's, which require isolation transformers to provide ground fault protection, are not acceptable.
- C. In addition, provide the following protection features.
 - 1. Input line-to-line and line-to-ground MOVs for transient protection up to 3000 volts.
 - 2. Control circuit transformer fusing.
 - 3. Grounded control chassis.
 - 4. Diagnostic indication.
 - 5. One set of spare fuses for each type used in drive for each VFD.
- D. Interlock VFD control circuits with driven motor's disconnect switches where such motor disconnect switches are provided. Disconnecting on-line motor shall shut down VFD. VFD shall restart upon reconnection of motor.
- E. VFD shall employ adjustable torque limit control, which shall override speed command and decrease frequency while maintaining correct volts/hertz ratio whenever load level surpasses VFD design level or set point.

2.07 OPERATING AND MONITORING DEVICES

- A. Door interlock to disconnect VFD input power.
- B. Manual stop/start device.
- C. Operating mode selector device marked "Manual-Off-Automatic".
- D. Manual speed control potentiometer.
- E. Power on indication.
- F. Drive run indication.
- G. Drive fault indication with testable feature.
- H. Fault reset device.
- I. Speed indicating meter or digital indication (0 - 100%) calibrated in percent speed or frequency meter with 0 to 90 Hz scale to indicate motor speed.
- J. Integral digital programming and operating display which shows Hz, Percent Output Current, Output Voltage, Percent Output Power, 89 Operating Parameters and their values, and Diagnostic Fault Codes. In addition, Keypads shall be incorporated to facilitate digital programming of drive adjustments. Analog potentiometer adjustments are not acceptable.
- K. Provision shall be included to provide selectable programming security by inhibiting program parameter changes with internal dip switch setting or with password security.
- L. Control shall incorporate microprocessors for operator interface, diagnostics, and fault managements, and power management.
- M. Optional DOS-based programming software, which includes provision for serial communication with drive, shall be available for shipment at time of equipment order placement.
- N. Fault buffers to sequentially store last 4 faults. Parameter and fault information to be stored in non-volatile memory.

2.08 QUALITY ASSURANCE TESTS

- A. Complete drive assembly shall be factory tested with actual AC induction motor, 100% load and temperature cycled within environment chamber at 40°C (104°F). Documentation of test shall be furnished to verify successful completion of test at Engineer's request.

2.09 DISCONNECT DEVICE

- A. Provide integral switch to disconnect incoming electrical power to units. Disconnect device shall be UL listed device of the following:
 - 1. Motor circuit switch: horsepower rated.
 - 2. Enclosed molded case breaker; ampere rated and providing over current protection.
 - 3. Molded case switch; ampere rated enclosed switch with or without over current protection.
 - 4. Rotary switch: with or without fuser.
- B. Unit shall have an interrupting rating not less than that of the upstream overcurrent device as shown on Electrical Drawings.

- C. Disconnect shall be capable of being padlocked in OFF position and complying with OSHA requirements. Operating handle shall indicate whether switch is "ON" or "OFF".
- D. Switch shall have dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position and to prevent closing of switch mechanism with door open. Provide defeater mechanism to defeat the interlock for user required access.

2.10 LINE REACTORS

- A. Series line reactors shall be designed for harmonic filtering service and shall be UL component recognized. Construction shall be copper wire wound on steel cores. Inductors shall be 3 phase. Series line reactors shall be sized at 3% impedance and appropriately for total connected load. Design maximum temperature rise for inductors shall be 115°C.
- B. Core shall be made of laminated grain oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core locked in place using vertical ties or rods.
- C. Windings shall be copper wire, MW35C (round) or MW36C (rectangular) or copper foil. Terminations shall be tin plated copper alloy ring lugs, UL recognized terminal blocks, or solid copper bus. Terminations shall be pressure crimped or TIG welded to windings. Sheet insulation shall be DuPont Nomex 410 of thickness meeting UL insulation systems.
- D. Inductors shall be double impregnated (vacuum/pressure impregnate and bake followed by varnish dip and bake). Insulation systems shall be rated Class H (180°C), 600 volt. Inductors shall be Hi-Pot tested (2500 volt, 60 Hz, 1 minute) line-to-line and line-to-ground.
- E. Inductors shall be air-gapped to avoid saturation. Inductance shall be measured under full load and shall be within $\pm 5\%$ of design value.
- F. Enclosure shall be steel with enamel finish and no knockouts. Enclosure shall be NEMA 1 construction with hinged lockable cover. Screened openings shall be provided for enclosure ventilation. Enclosure shall be built with integral mounting brackets for platform or wall mounting.

2.11 OUTPUT LC FILTER

- A. Output LC filter shall consist of gapped, three phase, iron core inductor; AC-rated polypropylene capacitors; and wire-wound resistors. Filter shall be rated for application at maximum fundamental system frequency of 60Hz at nominal system voltages up to 600V. Filter shall operate at maximum carrier frequency of 8kHz at 40% of fundamental voltage. Ambient temperature of operation shall be 40°C.
- B. Three phase inductors shall be designed for harmonic filtering service and for slowing rate of rapid current changes. Inductors shall be UL component-recognized and shall be built to comply with UL 508A Standard. Construction shall be of copper wire wound on magnetic grade steel. Inductors shall be sized appropriately for total connected load. Design maximum temperature rise for reactors shall be 115°C at rated current.
- C. Core shall be made of laminated grain-oriented electrical steel (grade M6 or better). Brackets shall be ASTM structural steel or structural aluminum. Coils shall be wedged in place and core shall be locked in place using vertical ties or rods.
- D. Windings shall consist of copper wire or of copper foil. Terminations shall be copper alloy ring lugs, UL-recognized terminal blocks, or solid copper bus. Sheet insulation shall be DuPont Nomex 410 of thickness as required for UL insulation systems.

- E. Inductors shall be air-gapped to control saturation. Inductance shall be measured under full load and shall be within 10% of design value.
- F. Completed inductors shall be impregnated with 100% solid epoxy resin. Insulation varnish systems shall be rated Class H (180°C), 600V.

2.12 ISOLATION TRANSFORMERS

- A. Provide isolation transformer similar to Square D DIT Type. Size transformer based on maximum kVA load of connected motor and in accordance with VFD manufacturer's recommendations.
- B. Three phase transformers shall be 60 Hz, 480 volt delta primary and 480Y/277 volt secondary.
- C. Transformers shall be air cooled, 2 winding type with minimum of four 2-1/2% full capacity primary taps, 2 above and 2 below full rated primary voltage.
- D. Transformers 25 kVA to 112.5 kVA shall have 115°C temperature rise above 40°C ambient, allowing 15% continuous overload without exceeding 150°C rise in same ambient. Transformers above 112.5 kVA shall have temperature rise of 80°C above 40°C ambient, allowing 30% continuous overload without exceeding 150°C rise in same ambient.
- E. Insulating material shall be in accordance with NEMA ST20 standard for 220°C UL component recognized insulation system.
- F. Maximum temperature at top of enclosure shall not exceed 50°C rise above 40°C ambient.
- G. Ventilation opening shall be designed to prevent accidental access to live parts.
- H. Transformer coils shall be continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.
- I. High grade silicon steel, non-aging with high magnetic permeability, low eddy current losses and low hysteresis is required of cores. Magnetic flux densities shall be below saturation point. Core laminations shall be clamped securely with sturdy steel members.
- J. Provisions shall be made to isolate core and coil from enclosure with no metal-to-metal contact. Rubber vibration absorbing mounts shall be used to isolate base of enclosure from core and coil assembly.
- K. Visibly ground transformer neutral to enclosure with flexible grounding conductor.
- L. Entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished with baked enamel.
- M. Provide grounded shield between primary and secondary windings. Electrostatic shield shall consist of one-turn strip-copper winding placed between transformer primary and secondary winding. Insulate ends to prevent shorting. Lead from one end of shield shall run to transformer enclosure for grounding. Electrostatic shield shall not change primary and secondary winding insulation level to ground.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Visually inspect equipment and components at time of delivery. Submit report to Engineer with list of items or deficiencies to be corrected.

3.02 INSTALLATION

- A. Install VFD system in accordance with details, approved shop drawings and manufacturer's instructions and recommendations.
- B. Provide field low voltage wiring of VFD system components. Provide field interconnecting wiring between VFD and by-pass starter if bypass starter is specified and the wiring is not installed at factory. Install wiring in metal conduit and in accordance with electrical sections of this specification and applicable electrical code.
- C. Provide control wiring between interlocks in VFD control circuits and driven motor's disconnect switches, where such motor disconnect switches are provided.
- D. Do not connect ground from one unit to another unit's cabinet.
- E. Use separate conduits for incoming and outgoing power conductors from each unit.
- F. Use separate conduit for control wiring for each unit. Control wiring shall not occupy same conduit as power wiring.
- G. Use minimum 18 ga shielded wiring with ground for control wiring.
- H. Install floor mounted drives, on minimum 3-1/2" high concrete housekeeping pad and minimum 3/4" thick neoprene pad similar to Mason Super W, 50 durometer.
- I. Isolation Transformers:
 - 1. Unless otherwise indicated, transformers below 75 kVA shall be wall or ceiling mounted. Transformers 75 kVA and above shall be floor mounted. Ample space shall be allowed for air circulation around all sides. Do not mount transformers below VFD equipment. Mount transformers above if conditions are tight.
 - 2. Make all connections through enclosure at sides near bottom with vinyl covered flexible metal conduit in lengths not to exceed 3 ft.

3.03 START UP

- A. Perform start-up of VFD in accordance with procedures as defined by manufacturer for proper operation.
- B. Adjust critical frequency avoidance feature to step over frequencies, which cause excessive vibration in driven equipment.

END OF SECTION 15060

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SECTION 15065 - MECHANICAL SUPPORTING DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15240 – Mechanical Noise and Vibration Control
- B. Section 15250 - Mechanical Systems Insulation
- C. Section 15900 - Ductwork (for additional duct supports requirements)

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. Provide all supporting devices as specified and as required for proper support of piping, ductwork, equipment, materials and systems.
- B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.

1.04 SUBMITTALS

- A. Shop Drawings for each piping system for all pipe sizes and all applicable equipment including, but not limited to, the following:
 - 1. Manufacturer's name.
 - 2. Model numbers.
 - 3. Materials of construction and load ratings (lbs).
 - 4. Schedule of hangers and support devices with pipe support spacing.
 - 5. Insulated pipe supports along with application chart or table.
 - 6. Insulation protection saddles and weight bearing insulation table.
 - 7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports.
 - 8. Structural attachments, inserts and concrete anchors.
 - 9. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments.
 - 10. Equipment mounting devices.
 - 11. Pipe guides and anchors.
 - 12. All other appropriate data.

1.05 DESIGN CRITERIA

- A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME Code for Pressure Piping B31.1 and MSS Standard Practice SP-58 (Materials, design and Manufacture), SP-69 (Selection and Application), and SP-89 (Fabrication and Installation Practices), except as supplemented or modified herein.
- B. Support materials shall be steel or stainless steel unless specifically indicated.
- C. Support devices shall be factory fabricated by manufacturers and have published load ratings.
- D. Unless otherwise indicated, design structural support members and support devices, including couplings, rods, trapeze supports and strut systems, with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
- E. Determine maximum deflection using the following equation:

$$D = \frac{H \text{ or } L}{250}$$

Where D = Maximum deflection in Inches
 H = Member height in Inches
 L = Member length in Inches

- F. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application. Coat cut edges, welds or any damaged finish with galvanized paint.
- G. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports. Plastic coated steel supports are acceptable.
- H. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect/Engineer.
- I. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing Work specified in Section 15250 - Mechanical Systems Insulation.
- J. In addition to hangers Specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater.
- K. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have flexible piping connections and vibration supports as indicated above. Flexible connections and vibration isolators are specified in Section 15240 – Mechanical Noise and Vibration Control.

- L. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
- M. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.
- N. Unless otherwise indicated, continuous insert channels are not allowed.
- O. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.
- P. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.
- Q. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of Work. This review may result in use of other welding codes or standards, which may apply to "structural work". Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.

PART 2 - PRODUCTS

2.01 STRUCTURAL SUPPORTS

- A. Provide all supporting steel, not indicated on structural drawings, that is required for installation of mechanical equipment and materials, including angles, channels, beams, etc. to suspend or floor support equipment.

2.02 PIPE HANGERS AND SUPPORTS (METALLIC)

- A. Manufacturers: Anvil (formerly Grinnell), Erico (formerly Michigan Hanger), Tolco, or B-Line, equal to Anvil figures listed.
- B. Hangers/supports for copper pipe where supports directly contact to pipe, shall be either copper plated or PVC coated.
- C. For insulated pipe supports, refer to Insulated Pipe Supports in Part 3 of this Section.
- D. Clevis and Roller Type Hangers:

<u>System</u>	<u>Pipe Size</u>	<u>Clevis</u>	<u>Roller</u>
Hot Pipes with Insulation (120°F and above)	2" and smaller	65, 260	---
	2-1/2" to 6"	---	171, 181

1. For pipe size 2-1/2" and larger, where there is transverse movement at support points due to thermal expansion/contraction, clevis type hangers similar to Anvil Figure 260 may be used if vertical angle of hanger rod is less than 4 degrees.

<u>System</u>	<u>Pipe Size</u>	<u>Clevis</u>	<u>Roller</u>
Ambient Bare Pipes (60°F to 119°F)	2" and smaller	65, 260	---
	2-1/2" and larger	260, 216	---

E. Flat Surfaces (Trapeze, Rack Type):

1. Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Refer to Part 1 for design criteria. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

<u>System</u>	<u>Pipe Size</u>	<u>Straps or Clamps</u>	<u>Rollers</u>	<u>Slides</u>
Hot Pipes with Insulation (120°F and above)	2" and smaller	243, 244	---	---
	2-1/2" and larger	---	177, 271, 274	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.
Ambient Bare Steel Pipes (60° to 119°F)	all sizes	137	---	---
Ambient Bare (Copper) pipes (60° to 119°F)	all sizes	137 with CT-169		

2.03 PIPE HANGERS AND SUPPORTS (NON-METALLIC)

- A. Manufacturers: Aickinstrut, B-Line, Strut-Tech, Unistrut, Litchfield International, equal to B-Line figures listed.
- B. Clevis Type Hangers:

<u>System</u>	<u>Pipe Size</u>	<u>Clevis</u>
Iron Pipe	6" and smaller	B-Line No. BFV3104 series

C. Clamp Type Hangers:

<u>System</u>	<u>Pipe Size</u>	<u>Clamp</u>	<u>Cushions</u>
Iron Pipe	6" and smaller	B-Line No. BFV-2000 Series Grilamid Clic Nylon 12	--

D. Channel Strut:

<u>System</u>	<u>Channel Size</u>	<u>Clamp</u>
Iron Pipe	1-5/8" x 1-5/8"	B-Line No. BFV-2000 Series

2.04 INSULATION PROTECTION SHIELDS

- A. Anvil Fig. 167 constructed of galvanized carbon steel. Select shield to accommodate outer diameter of insulation. Shield length and gauge shall be as follows:

<u>Pipe Size</u>	<u>Length</u>	<u>Gauge</u>
1/4" thru 3"	12"	18

2.05 INSULATION PROTECTION SADDLES

- A. Anvil Fig. 160 Series, constructed of carbon steel or alloy steel plate. Select saddles to accommodate insulation thickness specified in Section 15250 - Mechanical Systems Insulation.

2.06 WEIGHT BEARING INSULATION INSERTS

- A. Insert thickness shall match pipe insulation thickness. Pipe insulation jackets shall be continuous through sections containing inserts.
- B. Minimum length of inserts shall be 12" or 2" longer than insulation protection shields, whichever is longer. Quantity and placement of inserts shall be based on weight of pipe and fluid plus 1.5 safety factor.
- C. Hot Pipes (120°F and above):
1. High-density calcium silicate insulation (Type H) similar to Johns Manville Thermo-12 or cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas. Maximum compression strength for load calculation shall be 100 psi.
 2. HAMFAB H-Block by ICA Inc. may be used. Maximum compression strength for load calculation shall be 30 psi.

2.07 PRE-INSULATED PIPE SUPPORTS

- A. Shaw Pipe Shields, Inc. or Rilco equal to Shaw Pipe Shields models listed.
- B. Insulation shall consist of water-resistant calcium silicate of same thickness as adjoining pipe insulation, thermal conductivity not more than 0.38 at 75°F mean temperature, minimum density of 13 lb/ft³, and compressive strength not less than 100 psi.
- C. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of 32 lb/ft³ and minimum compressive strength of 600 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.

- D. Use vapor barrier steel jacket around insulation. Insulation jackets shall be galvanized steel conforming to ASTM A-527. Hanger bearing surface shall consist of galvanized sheet metal insulation protection shield or casing.
- E. When recommended by manufacturer, use double layer insulation protection shield at support bearing surface. Insulation shall extend 1" beyond insulation protection shield to maintain vapor barrier integrity.
- F. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following Codes and Standards: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.
- G. Load tests shall be made on both supporting materials and configurations. All tests shall be performed by independent testing laboratory. Results of pertinent tests shall be available on request.
- H. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Shaw Pipe Shields, Inc.:
 - 1. Pipe supported on hangers: Models A2000, A4000, A9000, D3000 and D3200.
 - 2. Pipe supported on flat surfaces: Models A2000, A4000, A6000, A7000, A7200, and A7400.
 - 3. Pipe supported on pipe rolls: Models A4000, A6000, A8000, A8200, and A8400.
 - 4. Pipe supported on slides: Model "B" Series.
 - 5. A1000, A3000 or A5000 may be used for hot pipes (120°F and above).
- I. Select proper model to conform to pipe service, support style, and support spacing.
- J. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.
- K. Pipe support spacing shall be in accordance with manufacturer's recommendations, but in no case shall exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.

2.08 HANGER RODS (METALLIC)

- A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.
- B. Rods shall have electroplated zinc or hot dip galvanized finish.
- C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated:

<u>Max. Pipe Size</u> <u>With Single Rod</u>	<u>Rod</u> <u>Diameter (inches)</u>	<u>Maximum Load (lbs.) of Hanger Rod</u> <u>(Not exceeding 650°F Service Temp.)</u>
2"	3/8	730
3"	1/2	1350
5"	5/8	2160
8"	3/4	3230

2.09 HANGER RODS (NON-METALLIC)

- A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.
- B. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule.
- C. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated.

<u>Max. Pipe Size</u>	<u>Rod</u>	<u>Maximum Load (lbs.) of Hanger Rod</u>
<u>With Single Rod</u>	<u>Diameter (inches)</u>	<u>(Not exceeding 200°F Service Temp.)</u>
6"	3/4"	3230

2.10 BOLTS, NUTS, STUDS AND WASHERS

- A. ASTM A307, electroplated zinc finish.

2.11 ROD ATTACHMENTS

- A. Anvil Fig. 290, galvanized finish.

2.12 U-BOLTS

- A. Anvil Fig. 137, galvanized finish.

2.13 BEAM CLAMPS

- A. Beam Clamps: Anvil Fig. 218, 228 and 292.
- B. Top Beam Clamps: Anvil Fig. 227.
- C. C-Clamps: Anvil Fig. 86, 92 or 93.

2.14 ADJUSTABLE PIPE SADDLE SUPPORTS

- A. Anvil Fig. 264.

2.15 RISER CLAMPS

- A. Anvil Fig. 261.
- B. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.16 CONCRETE ANCHORS

- A. Manufacturers: Powers, Hilti, or Red Head.
- B. Flush or shell type, meeting description in Federal Specification FF-S-325, Group VIII, Type 1 for expansion shield anchors, similar to Powers Power-Bolt. Anchors shall be zinc plated in accordance with ASTM B633, Sc. 1, and Type III.
- C. Select anchors with minimum safety factor of 8.0.

2.17 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

- A. Manufacturers: Unistrut, B-Line Strut Systems, Power-Strut, Superstrut, Kindorf, and Hydra-Zorb.
- B. Channels shall have epoxy paint or electroplated zinc finish.
- C. Channels shall not be lighter than 12 ga.

2.18 PIPE GUIDES

- A. Unless otherwise indicated, guides shall be Shaw Pipe Shields or Rilco equal to Shaw Pipe Shields "B" Series B3000, B4000, B7000, B8000, selected by load and movement.

2.19 PIPE ANCHORS

- A. Unless otherwise indicated, anchors shall be no-moment type, Shaw Pipe Shields or Rilco equal to Shaw Pipe Shields Insulated Positive Pipe Anchor Model C3000 or C4000 Series, sized to meet anchor forces shown with minimum safety factor of 3.0.
- B. Contractor may fabricate anchors of steel sections suitable for location of installation and for withstanding anchor forces shown with minimum safety factor of 3.0.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.
- B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.
- C. Coordinate hanger and support installation to properly group piping of all trades.
- D. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- E. Piping and ductwork shall be supported independently from other piping or ductwork.
- F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
- G. Do not support equipment or piping from metal roof decking.
- H. Install adequate supports during erection of piping so as not to over stress either piping or equipment to which piping is connected.
- I. Refer to Section 15050 - Basic Mechanical Requirements, for requirements of personnel injury protection guards for supporting devices.
- J. Feed mains parallel to joists shall not be supported from single joist. Feed mains parallel to joists shall be supported from trapeze hanger and be positioned equally between 2 joists. Trapeze hangers shall be positioned to load joists at panel points only.
- K. Provide plastic isolators at all clamps.

3.02 HANGER AND SUPPORT SPACING

A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein.

B. Steel Pipe (Standard Weight and Extra Strong):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/4" and smaller	7'-0"
1-1/2"	9'-0"
2"	10'-0"
2-1/2"	11'-0"
3"	12'-0"
4"	14'-0"

C. Copper Tube (Unless Otherwise Noted):

<u>Pipe Size</u>	<u>Max Spacing</u>
3/4" and smaller	5'-0"
1" to 1-1/4"	6'-0"
1-1/2" to 2-1/2"	8'-0"
3" and larger	10'-0"

D. Copper Tube (Domestic Water, Laboratory Water, Non-potable Water):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/4" and smaller	6'-0"
1-1/2" and larger	10'-0"

E. Cast Iron Pipe:

1. Maximum hanger and support spacing shall be 10 ft for all pipe sizes. Provide minimum of one hanger per pipe section close to joint on barrel, at each pipe fitting, at change of direction and branch connections.
2. Support Cast Iron No-Hub pipe as recommended in CISPI Publication "Cast Iron Soil Pipe and Fittings Handbook, Chapter IV - Installation of Cast Iron Soil Pipe and Fittings."

F. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.

G. Spacing less than indicated above may be required to conform with building structure design or loading limitations.

H. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.

I. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.

J. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.

- K. Install supports for vertical piping and anchors as recommended by pipe manufacturer.
- L. Place hangers and supports to meet requirements of Section 15511 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.
- M. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.
- N. Place hangers and supports within one foot of either side of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4" and larger.
- O. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.03 INSULATION PROTECTION SHIELDS

- A. Install insulation protection shields at support points as specified under Insulated Pipe Supports.
 - 1. Use one shield (bottom) for clevis hanger.
 - 2. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.

3.04 INSULATION PROTECTION SADDLES

- A. Install saddles at support points as specified under Insulated Pipe Supports. Tack weld saddle to pipe. Pack saddle cavity with insulation of same type as specified for piping system.

3.05 INSULATED PIPE SUPPORTS

- A. Install insulated pipe supports at support points of all insulated pipe.
- B. Pipe Size 1-1/2" and Smaller:
 - 1. Use insulation protection shields. Pipe insulation specified in Section 15250 - Mechanical Systems Insulation, shall be continuous through support points.
- C. Pipe Size 2" and Larger:
 - 1. Use pre-insulated pipe supports.
 - 2. In lieu of pre-insulated pipe supports, field-assembled insulated pipe supports may be used. If used, submit application details including materials, thickness, compression strength, load bearing surfaces, load calculations of support assembly and total pipe weight based on support spacing.
 - 3. Field-assembled insulated pipe supports shall consist of weight bearing insulation inserts and insulation protection shields.
 - 4. Insulation protection saddles may be used in lieu of assembled insulated pipe supports on roller hangers/supports for hot water pipes, low pressure steam and steam condensate pipes.

3.06 BEAM CLAMPS

- A. Provide locknut for hanging rod at clamp.
- B. C-clamps are allowed for rod size 3/8" and only for static loading such as air piping, cold water piping, fire protection piping and, other similar piping and ductwork. C-clamps are not allowed for hot water piping and steam and steam condensate piping, except hot water runouts to terminal heating devices.

3.07 TRAPEZE SUPPORTS

- A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.
- B. Determine trapeze supports spacing by the smallest pipe on trapeze.

3.08 CONCRETE ANCHORS

- A. Anchor application, size, and placement shall be reviewed and approved by Structural Engineer prior to installation.

3.09 PIPE GUIDES

- A. Install where shown on drawings.
- B. For manufactured expansion devices, install minimum of 2 pipe guides at each side of manufactured pipe expansion device. Locate first guide no more than 4 pipe diameters from expansion device and second guide at 14 pipe diameters from first guide. Install intermediate guides in accordance with guide spacing data recommended by manufacturer or the following table, whichever is more stringent:

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (FT)

<u>Pipe Size</u> <u>(inches)</u>	<u>Pipe Operating Pressure</u>			
	<u>0 to 50</u> <u>psig</u>	<u>51 to 100</u> <u>psig</u>	<u>101 to 150</u> <u>psig</u>	<u>151 to 200</u> <u>psig</u>
3	21	19	17	16
4	35	29	25	22
6	57	44	37	32

- C. If anchor is located within 4 pipe diameters from expansion joints, guides need not be installed on anchor side.

3.10 PIPE ANCHORS

- A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.
- B. Do not anchor piping to concrete block walls, wood, or partition walls.

END OF SECTION 15065

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SECTION 15084 - MECHANICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 - General Requirements.

1.02 SCOPE

- A. Work under this Section includes but is not limited to the following:
 - 1. Penetrations through fire-resistance-rated floor, roof, walls and partitions including openings containing pipes, ducts and other penetrating items.

1.03 SYSTEM PERFORMANCE REQUIREMENTS

- A. Firestopping systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.
- B. Firestop materials and methods shall conform to requirements of Local Code Authority Having Jurisdiction.

1.04 SUBMITTALS

- A. Manufacturer's specifications and technical data for each material including composition and limitations, documentation of UL Certification for firestop systems to be used and manufacturer's installation instructions.
- B. Material safety data sheets provided with product delivered to job-site.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has completed firestopping that is similar in material, design and extent as that indicated for Project and that has performed successfully.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and UL label where applicable.
- B. Store materials to prevent deterioration or damage due to moisture, temperature changes, contaminants or other causes.
- C. Handle in accordance with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

1.07 PROJECT CONDITIONS

- A. Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturer or when substrates are wet due to rain, frost, condensation or other causes.

- B. Ventilate firestopping per manufacturers' instructions by natural means or, where this is inadequate, forced air circulation.

1.08 SEQUENCING AND SCHEDULING

- A. Do not cover up those firestopping installations that will become concealed behind other construction until authorities having jurisdiction, if required, have examined each installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc, or Rectorseal Corp.
- B. Pro-set firestop products may be used for specific applications, provided products meet requirements in this Section.

2.02 MATERIALS

- A. Use only firestop products that have been UL 1479, ASTM E-814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance.
- B. Materials shall not contain flammable solvents.

2.03 MIXING

- A. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean out openings immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer.
- B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
- C. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.03 INSTALLATION

- A. Comply with "System Performance Requirements" Article in Part 1 and manufacturer's installation instructions and drawings.
- B. Install forming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and materials have cured, remove forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Avoid multiple penetrations of common fire barrier opening. Seal each penetration in accordance with manufacturer's UL installation details. When multiple penetrations are unavoidable, seal openings with appropriate UL Classified firestopping systems.

3.04 FIELD QUALITY CONTROL

- A. Inspecting Agency: Owner will engage a qualified independent inspecting agency to inspect Through-Penetration Firestop Systems and to prepare test reports.
 - 1. Inspecting agency will state in each report whether inspected Through-Penetration Firestop Systems comply with or deviate from requirements.
- B. Provide certification by Installer that all Through-Penetration Firestop Systems have been firestopped in accordance with applicable Building Codes of this State.
- C. Proceed with enclosing Through-Penetration Firestop Systems with other construction only after inspection reports are issued.
- D. Where deficiencies are found, repair or replace Through-Penetration Firestop Systems so they comply with requirements.

3.05 IDENTIFICATION

- A. Identify Through-Penetration Firestop Systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
 - 1. The words: "Warning--Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage."
 - 2. Contractor's name, address, and phone number.
 - 3. Through-Penetration Firestop System designation of applicable testing and inspecting agency.
 - 4. Date of installation.
 - 5. Through-Penetration Firestop System manufacturer's name.
 - 6. Installer's name.

3.06 CLEANING

- A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as Work progresses.

END OF SECTION 15084

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SECTION 15190 - MECHANICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.
- B. American National Standards Institute (ANSI)
 - 1. ANSI A13.1 "Scheme for the Identification of Piping Systems".
 - 2. ANSI Z53.1 "Safety Color Code for Marking Physical Hazards".

1.02 SUBMITTALS

- A. Product Data: For identification materials and devices.
- B. Valve Schedules: For each piping system.
- C. Samples: Of color, lettering style, and graphic representation required for each identification material and device.

PART 2 - PRODUCTS

2.01 IDENTIFYING DEVICES

- A. Pressure Sensitive Markers:
 - 1. Brady type 350 flexible vinyl film identification markers and tape, with legend, size and color coded per ANSI A13.1.
- B. Semi-rigid Plastic Identification Pipe Markers:
 - 1. Seton Setmark with legend, size and color coding per ANSI A13.1. Direction of flow arrows are to be included on each marker, unless otherwise specified.
 - a. Setmark type SNA markers to be used on pipe diameters $\frac{3}{4}$ " thru 5".
 - b. Setmark type STR markers to be used on pipe diameters 6" or larger.
- C. Valve Tags:
 - 1. Minimum 1-1/2" diameter, 0.032" thick, polished brass round discs, brass chain.
- D. Laminated Plastic Nameplates:
 - 1. Nameplates shall be approximately 1-1/2" x 4", 1/16" thick, and have 1/2" high lettering. Face of plastic nameplates shall be light contrasting background color with engraved black letters.
 - 2. Fasteners shall be self-tapping, brass screws or contact type with permanent adhesive.
 - 3. Nameplates shall bear the same identifying legend used on the Contract Documents.

PART 3 - EXECUTION

3.01 GENERAL

- A. After painting and/or covering is completed, identify equipment and piping as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.

- B. Where markers are used in high heat applications or exposed to harsh chemical or acid environments, specifically select marker materials for those applications.

3.02 PIPING SYSTEM IDENTIFICATION

- A. Install pipe identification on each system. Place flow directional arrows at each pipe identification location, pointing away from the pipe legend.
- B. Fire protection pipe identification shall have a red background with white letters.
- C. Identify all piping not less than once every 25 ft, not less than once in each room, at each branch, adjacent to each access door or panel, at each valve and where exposed piping passes through walls and floors.
- D. Painted Stencils:
 - 1. Pipes and equipment to be stenciled shall first be wiped clean of dust, dirt, rust, grease and moisture.
 - 2. Prepare surfaces in accordance with Section 09900- Painting for stencils.
 - 3. Pipes and equipment shall be painted with required color code to a smooth hard surface in the area the stencil is to be applied.
 - 4. Stenciled markings shall be neatly performed with no overspray, drips or other imperfections.
 - 5. Legend letters and color field size as specified for Paint Stencils in subparagraph G of this paragraph
 - 6. Paint application shall comply with Section 09900- Painting.
- E. Pressure Sensitive Markers: Apply pressure sensitive markers in accordance with manufacturer's recommendations with complete wraparound. Marker adhesion will be tested for permanence. Any markers showing dog ears, bubbles or other failings shall be replaced.
- F. Semi-rigid Plastic Identification Markers: Seton Setmark pre-molded (not pressure sensitive) identification markers may be used at Contractor's option on service piping which is accessible for maintenance operations (but not on piping in finished spaces). The type of marker shall not be installed on bare pipe with surface temperature exceeds 180 degrees F unless a 1" thick insulation band is first provided under marker for protection from the hot surface of the pipe.

3.03 CONTROL VALVE IDENTIFICATION

- A. Identify valves with brass tags bearing system identification and valve sequence number in 1/2" black characters. Attach tag to valve body with brass jack chain and "S" hook for brass tag and SS jack chain or SS braided wires with swag sleeves and "S" hook for stainless steel tag. Non-metallic fasteners are not allowed.
- B. Valve numbers shall be prefixed with corresponding piping system identification in 1/4" black letters.
- C. Valve tags are not required at terminal devices unless valves are greater than 10 ft from device or located in another room not visible from terminal unit.

3.04 EQUIPMENT IDENTIFICATION

- A. Identify major equipment, including air handling units, fans, boilers, chillers, heat exchangers, air terminal devices, pumps, water heaters, tanks, compressors, etc.
- B. Identify equipment by stenciling equipment number and service in 2" high letters.

- C. Identify control equipment and panels with laminated plastic nameplates. Attach nameplates with brass screws. Pressure sensitive embossed labels are not acceptable.
- D. Locate motor nameplates for easy reading. Relocate or provide new nameplates on motors if original nameplates are not located for easy reading.

3.05 ACCESS PANEL, LIFT-OUT CEILINGS AND ACCESS DOOR IDENTIFICATION

- A. Provide Kroy type adhesive labels on ceiling tee or access door to identify concealed valves, air terminal units, fire/smoke and fire dampers, or similar concealed mechanical equipment which is directly above nameplate in ceiling place.
 - 1. Provide following colors for specified labels:
 - a. Fire-protection devices, including dampers: 3/8" red letters on white background.
 - b. Air-handling terminal devices: 3/8" black letters on white background.
 - c. Isolation, balancing and control valves: 3/8" black letters on white background.
 - 2. Label shall be installed oriented to read towards ceiling tile that needs to be removed for access.
- B. Furnish typewritten charts with identification and location of all access panels serving equipment and valves and incorporate in O&M Manuals.

END OF SECTION 15190

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SECTION 15240 - MECHANICAL NOISE AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. This Section is valid only when considered in total with all other Contract Documents. References are for the convenience of the reader and their inclusion in or omission from any Section in no way limits the scope or intent of the Contract Documents.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. General Properties.
 - 2. Isolator Description.
 - 3. Equipment Frames.
 - 4. Equivalent Vibration Isolators and Equipment Frames.
 - 5. Motion Restraints.
 - 6. Vibration Isolator Application and Schedules.
 - 7. Piping and Duct Resilient Support and Suspension.
 - 8. Duct Gauge to Control Breakout Noise.
 - 9. Flexible Duct Connections.
 - 10. Flexible Piping Connections.
 - 11. Resilient Penetrations.
 - 12. Acoustical Duct Lining.
 - 13. Plenum Lining.
 - 14. Mechanical Unit Acoustical Requirements.
 - 15. Terminal Units Acoustical Requirements.
 - 16. Diffuser, Grille, and Register Acoustical Requirements.
 - 17. Sound Traps.

1.3 RELATED WORK

- A. The following sections contain requirements that relate to this section.
 - 1. Mechanical, Division 15
 - 2. Electrical, Division 16

1.4 SCOPE OF WORK

- A. Objective: It is the objective of this specification to provide the necessary design for the avoidance of excessive noise or vibration throughout the project due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

- B. Description of Work: Furnish, install, assemble, set up, test (hereinafter "provide") the following systems and equipment in accordance with the Contract Documents.
1. Vibration isolation of mechanical equipment including but not limited to fans, package air conditioning/handling units, refrigeration compressors, chillers, cooling towers, and pumps, including bases.
 2. Isolation for ductwork and piping including but not limited to, domestic hot and cold water, waste, soil, vent piping and including all piping connected to vibrating equipment.
 3. Supervision and inspection of installation of vibration isolation to equipment.
 4. Provision of acoustical lining, sound traps and terminal units in accordance with the Acoustical Performance requirements of this Section.
 5. Provision of all Motion Restraints required by applicable codes for noise and vibration control equipment/systems specified herein.
 6. Coordination of Airtight Installation requirements at Mechanical Rooms and/or duct enclosures.

1.5 REFERENCES

- A. Standards: Provide equipment in accordance with the latest edition and revisions of all applicable standards and specifications of all appropriate agencies including, but not limited to, the following:
1. ANSI - American National Standards Institute
 2. ASTM - American Society for Testing and Materials
 3. ASME - American Society of Mechanical Engineers
 4. ASA - Acoustical Society of America
 5. ADC - Air Diffusion Council
 6. AMCA - Air Movement and Control Association
 7. ARI - Air-Conditioning and Refrigeration Institute
 8. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
 9. NFPA - National Fire Protection Association
 10. ASC - Adhesives and Sealants Council
 11. SMACNA - The Sheet Metal and Air-Conditioning Contractor's National Association.
 12. NVLAP - National Voluntary Laboratory Accredited Program.
- B. Codes: Perform installation in accordance with all applicable international, federal, state, county, municipal and local codes and regulations.
- C. Conflicts: Present any conflicts between codes, regulations, specifications and/or requirements at least thirty (30) days prior to the commencement of the scheduled work.
- D. Related Provisions: Division 1 - General Provisions, and Division 15 - General Provisions apply to the work of this Section.
- E. Schedules: See contents of this Section for specific schedules of equipment sound power levels, vibration isolators, frames, isolator static deflections, and sound traps.

1.6 QUALITY ASSURANCE

- A. Product Suppliers: All vibration isolation mounts, bases and frames for equipment and piping furnished under all Division 15 Sections shall be designed and furnished by a single isolator manufacturer.

- B. Supervision: The installation of all vibration isolation units, and associated hangers and bases shall be in strict conformance with the submitted manufacturer's instructions; alternatively the equipment may be installed by the vibration isolation manufacturer or under the direct supervision of the vibration isolation manufacturer's representative.

1.7 INSPECTION OF CONDITIONS

- A. Examine related Work and surfaces before starting Work of this Section. Report to the Architect, in writing, conditions which will prevent proper provision of this Work. Beginning the Work of this Section without reporting unsuitable conditions to the Architect constitutes acceptance of such conditions by Contractor. Perform any required removal, repair, or replacement of this Work caused by unsuitable conditions at no additional cost to the Owner.

1.8 COORDINATION

- A. Coordinate the work of this Section, per Division 1, with the work of related Sections including: Finish Systems; Piping Systems and Equipment, Water Cooling and Heating, Plumbing Systems, Heating, Ventilating and Air Conditioning (Division 15); and Electrical sections (Division 16), including but not limited to Section 16190. Coordinate with Structural Concrete trade for equipment inertia bases. Coordinate Work of this Section with all other impacted trades.

1.9 SUBMITTALS

- A. Refer to Division 1 and other Sections of Division 15 for rocedures.
- B. Descriptive Data - Submit the following:
 - 1. Catalog cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications and schedules herein. Include load versus deflection curves.
 - 2. An itemized list showing the items of equipment, ductwork, piping, etc., to be isolated, the isolator type and model number selected, isolator loading, deflection and spring diameter, and references to specific shop drawings showing frame construction where specified.
 - 3. Written approval of the frame design to be used, obtained from the equipment manufacturer.
 - 4. Written instructions from the vibration isolation manufacturer as to the proper installation and adjustment of vibration isolation devices, including hangers and bases; alternatively the equipment may be installed by the vibration isolation manufacturer.
 - 5. An itemized list of all items of equipment to be fitted with flexible piping and/or duct connections. Flexible piping and/or duct submittals shall contain all information and calculations to demonstrate conformance and suitability for the equipment operating conditions including but not limited to pressure, temperature, capacity, mounting, maintenance, etc.
 - 6. A schedule of airtight and resilient sleeves which will be used where ducts, pipes and/or conduit penetrate building constructions which provide sound isolation, including where necessary in order to maintain airtight mechanical rooms.
 - 7. Manufacturer's sound trap construction details, certified test results for both dynamic insertion loss (forward air flow) and self noise; and a complete description of test conditions and measurement procedure in strict compliance with the requirements of this Section.
 - 8. Catalog cuts for acoustical duct lining and plenum lining.

9. Certified acoustic test data for terminal units. Provide maximum casing radiated and discharge noise PWL and SPL in accordance with ARI 880.
 10. Certified acoustic test data for mechanical units identified in 2.13.A.1. Provide acoustic test data in accordance with the specified procedures.
- C. Shop Drawings - Submit the following and secure approvals prior to fabrication:
1. Drawings showing equipment frame construction for each machine, including dimensions, structural member sizes, support point locations, etc.
 2. Drawings showing methods for suspensions, support, guides, etc., for piping and ductwork, etc.
 3. Drawings showing methods for isolation of ducts, pipes, etc., piercing walls, slabs, beams, etc.
 4. Drawing showing methods, numbers and details of Motion Restraints and anchors for equipment, frames, isolators, piping, ductwork, etc., including calculations as above.
 5. Details for concrete and steel bases including anchor bolt locations.
 6. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, showing compliance with Code and coordination with the project Architectural, Structural and Mechanical Documents.
 7. Details of flexible piping and duct connections for all typical conditions listed in the schedule provided above.
 8. Drawings showing size and location of sound traps to be supplied.
 9. Duct layout drawings showing all register and duct sizes. Show extent of acoustical duct lining. Show air volume under proposed initial balance conditions with sufficient detail to permit review of air velocities.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.
- B. Isolators shall be treated to resist corrosion.
- C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.
- D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.
- E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
- F. Coordinate selection of devices with isolator and equipment manufacturer.

2.2 MANUFACTURERS

- A. Mason Industries, Amber/Booth Co., Aeroflex-VMC-Korfund. Vibration Eliminator or Kinetics equal to manufacturer's model listed, except flexible pipe connections.
- B. Mason, Metraflex, Proco, Twin City Hose or Engineered Flexible Products (EFP) for flexible pipe connections.

2.3 GENERAL PROPERTIES

- A. Spring vibration isolators shall have either known undeflected heights or other markings so that, after adjustment, when carrying their load, the deflection under load can be verified. This determines that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided.
- B. Isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range 50 percent above the design deflection.
- C. Ratio of lateral to vertical stiffness for spring isolators shall not be less than 0.9 to 1.5.
- D. Vertical natural frequency for each support point, based upon the load per isolator and isolator stiffness, shall not differ by more than ± 10 percent.
- E. Wave motion through the isolator shall be reduced to the following extent: Isolation above the primary vertical system resonance frequency shall follow the theoretically predicted isolation curve for single degree of freedom systems within 10% up to 50 dB or greater at all frequencies above 150 Hz.
- F. All neoprene mountings shall have a Shore-A hardness of 30 to 50, after minimum aging of 20 days or corresponding oven-aging.

2.4 ISOLATOR DESCRIPTION

- A. For applications and the specific static deflection requirements of the isolators described below in each application, refer elsewhere herein.
 - 1. Type MS & MSSR: Bare spring type equipped with leveling bolts and with two layers of ribbed or waffled neoprene pad, separated by a 1/16" galvanized steel plate, under the base plate. Type MSSR shall be fabricated with integral steel housing, with inspection ports, providing all-directional motion restraint.
 - 2. Type MSL: Bare spring type with two layers of ribbed neoprene pad with 1/16" galvanized steel separator between layers under the base plate. Provide limit stops to prohibit spring extension if the load is removed. These stops shall serve as rigid blocking during erections so that the installed and operating heights shall be the same. Provide a minimum of 1/2" clearance around restraining bolts and between the limit stops and the housing so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation.
 - 3. Type HW: Suspension hanger with a free-standing, laterally stable steel spring and elastomer washer. Spring shall have a minimum additional travel to solid spring condition of 50% of rated deflection. Hanger shall be provided with eye bolts for the attachment of wire or duct straps. Hanger assembly shall be designed to permit misalignment of the hanger rod up to 15° relative to the vertical without touching the hanger box frame.

4. Type HS: Suspension hanger with a steel frame and having a spring element in series with a nominal 1 inch thick neoprene element with integral grommet. The design static deflection under load shall be as shown on the schedule. The isolator shall be designed so hanger rod may be misaligned up to 15° relative to the vertical without touching integral grommet inset in hanger box frame.
5. Type HD: Spring hangers, precompressed. Same as Type HS with washer and nut assembly for load transfer and an indicator for deflection readout.
6. Type HN: Suspension hangers with a neoprene or precompressed fiberglass isolation element having a minimum static deflection range of 0.25" to 0.5" designed to preclude contact of hanger rods with frame at up to 15° misalignment.
7. Type MN: Neoprene isolator mount having a minimum static deflection range of 0.25" to 0.5".
8. Type NSP: Neoprene or precompressed fiberglass pad. Neoprene pads shall be waffled or ribbed. Pads typically 5/16" to 3/4" thick with a typical static deflection of 0.05" to 0.10". Neoprene shall have a durometer of 50 maximum (40 Nominal). Nominally designed for 0.05" static deflection under 60 psi load. Provide steel load distribution plates. Size of pad to be selected by isolator supplier based on load per point. Precompressed molded fiberglass shall be coated with a flexible, moisture impervious elastomeric membrane.
9. Type SB: Rubber-in-shear sway brace assembly. Double neoprene pad. Durometer of 60 maximum. Static deflection typically .375". Generally spaced 4 ft. o.c. horizontally and vertically.
10. Type TR: Horizontal Thrust Restraints. Spring element in series with a 1/4" neoprene pad between base plate and spring. Spring element shall have the same deflection as specified for mountings or hangers. The spring element shall be contained within a steel frame and designed to be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop. The assembly shall be furnished with one rod and angle brackets for attachment to both equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit.

2.5 EQUIPMENT FRAMES

- A. General Properties: Mounting frames and/or brackets shall be provided to carry the load of the equipment without stressing or causing mechanical distortion of the equipment. Each piece of equipment shall be supported at a minimum of four points by vibration isolators and restrained at a minimum of four locations by Motion Restraint.
 1. Rigid Steel (RS): Rectangular rigid steel mounting frames shall be rectangular in design and shall consist of a minimum of four pieces of welded, wide flange structural steel with welded height saving brackets to accept the isolators. Additional frame members shall be provided as necessary to support pumps, motors, etc. The section depth of the frame members shall be greater than 1/10 of the length of the longest frame member, and shall be constant in all four perimeter frame pieces.
 2. Concrete Inertia Bases (CI): Concrete bases shall utilize welded structural forms. The forms shall include 1/2" (minimum) steel reinforcing bars welded in place on at least 6" centers running in both directions. The bottom edge of the steel bars shall be 1-1/2" from the bottom of the base. Provide drilled steel members with threaded sleeves welded below the holes to receive equipment anchor bolts. Provide height-saving brackets at all mounting locations. The base weight shall be at least equal to the weight of the mounted equipment. Concrete shall be not less than 6" in thickness. Provide a minimum clearance of 2" between the concrete base and the floor slab or housekeeping pad.

3. Type BR: Brackets to equipment. Height saving brackets attached directly to equipment where rigidity of same does not require supplemental frame.
4. Type TS: Trapeze. Used to distribute load or to conserve space. Supporting sling of steel members with mounts for hangers at each end. The section depth of the frame members shall be greater than 1/10 the length of the longest frame member.
5. Rooftop Curb Isolation Base (RTB): An rectangular equipment frame of upper and lower rail members connected with steel springs. The RTB is fitted between the roof curb and the equipment to be isolated and is integrated with the roof insulation and canting. Removable cover plates are provided for isolator inspection. Members shall house type MS spring isolators having 50% additional travel to solid. Spring diameter shall be no less than 0.8 of the spring height at rated load. Springs located to assure uniform loading and deflection. Resilient snubbers as necessary for wind resistance shall have a minimum clearance of 1/4" so as not to interfere with spring action. Overturn/lift restraints as necessary shall not interfere with spring action. Continuous air and weather seals shall consist of a closed-celled sponge material at mating surfaces with the equipment and curb and a flexible, duct-like connection joining the outside perimeter of the upper and lower members.

2.6 EQUIVALENT VIBRATION ISOLATORS AND EQUIPMENT FRAMES

A. Acceptable subject to above:

<u>Type</u>	<u>Description</u>	<u>Mason</u>	<u>Vibrex</u>	<u>Kinetics</u>
MS	Spring Mount	SLF*	RMS*	FDS*
MSSR	Spring Mount - Restrained	SSLFH	RMSP-EQ	FYS
MSL	Spring Mount w/ Limit Stop	SLR*	RMLS*	FLS*
HW	Spring Hanger	W30*	--	SH*
HS	Spring Hanger	30N*	HXA*	SRH*
HD	Spring Hanger	PC30N*	PHXAP*	--
HN	Neoprene Hanger	HD*	HSS*	RH*
MN	Neoprene Mount	ND*	FU*	RD*
NSP	Neoprene or Fiberglass Pad	W	R	NPD or KIP
SB	Wall Sway Brace	DNSB	FWU	PSB
RTB	Rooftop Curb Isolation Base	RSC	--	KSCR
TR	Thrust Restraints	WB	--	HSR

2.7 VIBRATION ISOLATOR APPLICATION AND SCHEDULES

A. General: The isolator type scheduled shall be furnished and installed for the following mechanical equipment in accordance with Part 3 herein, loaded to yield the specified deflection per the schedule below at each isolator. The isolator type and deflection shall be in compliance with ASHRAE 2003 Applications Handbook, Chapter 47, Table 42, unless indicated otherwise on the drawings.

B. Unless specifically listed in the table below, all equipment shall have isolator types and deflections in compliance with ASHRAE 2003 Applications Handbook, Chapter 47, Table 42.

1. The following is a recommended vibration isolation schedule for the project:

Equipment Types	Base Type ⁽⁶⁾	Isolator Type ⁽⁶⁾	Static Defl (in.)	Mason Ind. Type ^(1, 6)
Fans				
Floor/Roof Supported ^(3, 10)	Per Mfr ⁽⁷⁾	Spring	2.0	SLF
Suspended ⁽¹⁰⁾	Per Mfr ⁽⁷⁾	Sprg/Neop	2.25	30N
Mechanical and Domestic Piping ⁽⁴⁾	as req'd			
Floor Supported		Spring	1.0	SLR
Suspended		Sprg/Neop	1.25	30N
Steam		Neoprene	0.35	HD or ND
All Lab and Shop Equipment ⁽⁹⁾	per Mfr.	Spring	1.0	KSL or SLR

- (1) All isolation devices are to be Mason Industries or approved equal.
- (2) Equipment and devices within piping system to be isolated similar to connected piping or equipment.
- (3) Equipment manufacturer isolation acceptable.
- (4) All water piping within MER, but not less than 50 feet of equipment or pressure reducing stations, and all piping 4 inches and larger within and/or suspended from occupied floor.
- (5) Internal isolation for transformer cores complying with the above tabulated isolation type and ratings is acceptable.
- (6) Seismic restraints as required for project are to be separate of vibration isolation devices, and shall not degrade vibration isolation. Extent and type of seismic restraints by others.
- (7) Vibration isolation scheme to consider fan operating force and provide thrust restraint and/or concrete inertia base in order to limit movement of fan to 1/4 inch at any operating point. Thrust restraints to have the same deflection as vibration isolation devices.
- (8) In-line pumps to be mounted per manufacturer's recommendations.
- (9) All lab and shop equipment, including, but not limited to, Air Compressors, Vacuum Pumps, De-ionized Water Pumps, are to have vibration isolation mounts and/or hangers.
- (10) All ductwork and piping attached to vibration isolated equipment to be attached with flexible connections.
- (11) Unit casing isolation not required if fan is internally isolated and no other reciprocating or rotating equipment is contained within the unit.

2.8 PIPING AND DUCT RESILIENT SUPPORT AND SUSPENSION

A. Refer elsewhere in this Section for the requirements of Resilient Penetrations and Flexible Connections. Refer to Part 3 for the extent of the resilient piping support cited below.

1. At horizontal suspended pipe 2" and smaller connected to vibrating equipment over 1/2 HP provide Type HS isolator or floor supported Type MSL isolator with a minimum static deflection of 1.0". At horizontal suspended piping larger than 2" provide type HD isolator or floor supported Type MSL isolator with a minimum of 1-1/2" static deflection.
2. At supported vertical riser piping attached to vibrating equipment over 1/2 hp and over 1" O.D., provide Type MS isolators selected for a minimum static deflection of 1.0".

3. At pipe anchors for piping attached to vibrating equipment provide Types MN or HN to avoid direct contact of piping with building.
 4. Pipe sway braces where required and attached to vibrating equipment shall utilize neoprene elements of 40 durometer at least 3/8" thickness, Type MN to accommodate tension and compression forces.
- B. At horizontal Domestic water piping provide Armstrong Armaflex at each pipe hanger rigging point or clamp specified under Division 15. At vertical runs provide Type MN mounts attached to pipe clamps furnished elsewhere in Division 15.
- C. At ducts with air velocities greater than 1200 FPM provide Type MSL if roof/floor supported, or Type HW if suspended. Penetrations of shaft assemblies by such ductwork shall be non-rigid as described elsewhere in this Section.
- D. At vaneaxial fans operating against a static of 3" w.g. or greater provide neoprene/spring thrust snubbers, type WB by Mason or equal by Vibrex or Kinetics.

2.9 FLEXIBLE DUCT CONNECTIONS

- A. Flexible connection fabric shall be a non-combustible water-proof, airtight, glass fabric, one side coated with Neoprene, weight 20 ounce per square yard. For ducts operating at over 100^o F and for acid resistant applications, flexible fabric shall be 30 ounce Neoprene coated glass fabric. All fabric shall meet the applicable Code of the project jurisdiction.
- B. Acceptable Manufacturers subject to the above:
1. Ventfabrics, Inc.
 2. Duo-Dyne
 3. Elgen

2.10 FLEXIBLE PIPING CONNECTIONS

- A. Provide flexible piping connections between piping and vibrating equipment including but not limited to: pumps, cooling towers, air handling unit coils and compressors.
1. Provide flexible piping connections to pumps via double bellows flexible neoprene connectors consisting of multiple plies of nylon tire cord fabric and neoprene. Connectors up to and including 1-1/2" diameter may have threaded ends. Connectors 2" in diameter or larger shall be manufactured with floating metal flanges recessed to lock the connector's raised face neoprene flanges.
 2. Connectors shall be rated a minimum of 150 psi at 220^o F. Flanged equipment shall be directly connected to neoprene elbows in the size range of 2-1/2" to 12" diameter if the piping makes a 90^o turn at the equipment. All straight through connections shall be made via twin sphere configuration per 1 above.
 3. Acceptable products subject to above:
 - a. Mason Industries, Inc. MFNEC (elbow)
 - b. Mason Industries, Inc. MFTFU (straight)
 - c. Mason Industries, Inc. MFTNC (straight)
 - d. or equal by Mercer Rubber Co. or Keflex.

B. Metallic hoses:

1. Provide subject to 1. above where required by mechanical requirements. Metallic hoses shall always be installed in pairs, one in the vertical and one in the horizontal to provide full three degrees of freedom.
2. Acceptable Manufacturers subject to above:
 - a. Mason Industries
 - b. Mercer Rubber
 - c. Keflex
 - d. or equal, subject to prior approval.

2.11 RESILIENT PENETRATIONS

A. For piping, ductwork or conduit

1. Sleeves of appropriate gauge galvanized sheet metal shall be formed to at least the thickness of the penetrated construction and 3/4" to 1" larger in each cross-sectional dimension than the penetrating element. Opening between sleeve and pipe or duct element shall be packed with fiberglass or mineral fiber of 1 to 3 lb./cu. ft. density and shall be sealed airtight with non-hardening acoustical sealant.
2. Acceptable fiberglass or mineral fiber manufacturers subject to the above:
 - a. Certain-Teed
 - b. Schuller
 - c. Owens-Corning
3. Acceptable non-hardening acoustical sealant manufacturers subject to the above:
 - a. G.E.
 - b. Pecora
 - c. Tremco
 - d. Dow Corning
 - e. or equal, subject to prior approval.
4. Where required, resilient fire caulking and/or foams may be used in lieu of Acoustical Sealant when installed in strict conformance with the manufacturer's directions.
5. Acceptable resilient fire caulking manufacturers subject to the above:
 - a. G.E.
 - b. Dow Corning
 - c. 3M
 - d. Nelson
 - e. or equal, subject to prior approval.

B. For piping penetrations (alternative method):

1. A factory-fabricated sleeve assembly with outer sleeve of sheet metal and inner resilient liner of moisture-and vermin-resisting felt, neoprene, glass fiber or closed-cell foam rubber 1/2 to 3/4" thick and bonded to the sheet metal sleeve. Sleeve inside diameter shall be equal to outside diameter of penetrating element. Sleeve length shall be at least equal to the thickness of the penetrated construction.
2. Acceptable products subject to the above:
 - a. Mason Type SWS
 - b. Kinetics Type PS-1-D
 - c. Potter-Roemer PR-Isolator

- d. Stoneman Engineering Trisolator
- e. or equal, subject to prior approval.

2.12 MECHANICAL UNIT

- A. Coordinate the following Maximum Mechanical Equipment Sound Power Levels with the Equipment specified elsewhere in Division 15.
- B. Maximum mechanical equipment sound levels
 - 1. Testing: Mechanical units shall be tested to, and comply with, all requirements of this Specification. Representative samples shall be subjected to tests in accordance with applicable standards and procedures in order to demonstrate such compliance. All measurements shall be made in accordance with ARI/ADC (Air-Conditioning and Refrigeration Institute/Air Diffusion Council) by a independent, NVLAP (National Voluntary Laboratory Accredited Program) accredited laboratory.

2.13 TERMINAL UNITS

- A. Testing: Terminal units shall be tested to, and comply with, all requirements of this Specification. Representative samples shall be subjected to tests in accordance with applicable standards and procedures in order to demonstrate such compliance. All measurements shall be made in accordance with ARI/ADC (Air-Conditioning and Refrigeration Institute/Air Diffusion Council) by an independent, NVLAP (National Voluntary Laboratory Accredited Program) accredited laboratory.
- B. Lining: At casings, provide Acoustical Duct Lining as specified elsewhere herein.
- C. Connections: Provide flexible duct connectors, as specified elsewhere, between discharge of units and ensuing ductwork.

2.14 DIFFUSER, GRILLE, AND REGISTER

- A. Testing: Air distribution and collection devices shall be tested in accordance with applicable standards and procedures by an independent, NVLAP (National Voluntary Laboratory Accredited Program) accredited laboratory in order to demonstrate compliance with all requirements of this Specification.
 - 1. All measurements shall be made in accordance with ADC (Air Diffusion Council) Test Standard 1062 GRD 84.
 - 2. The results of the tests shall be certified by the testing agency, and submitted to the Architect for approval. The submittal shall include a complete description of the test conditions and the measurement procedure.

2.15 SOUND TRAPS

- A. General: Sound trap shall be factory assembled unit, tested and certified by an independent, NVLAP (National Voluntary Laboratory Accredited Program) accredited acoustic testing laboratory and clearly labeled showing manufacturer, type and direction of airflow.
- B. Construction:
 - 1. Casing shall not be less than 22 gage galvanized steel and baffling shall not be less than 26 gage perforated galvanized steel in accordance with specified construction for medium pressure ductwork. Seams shall be locked form and mastic filled.

2. Acoustical fill shall be inorganic long fiberglass or mineral fiber packed under not less than 5% compression, and shall have a flame spread classification of 25, smoke development rating 15, and fuel contribution 20.
3. Where required by Code, all sound traps on the discharge side of air filters shall have 0.5 mil Mylar facing on the insulation between the insulation and the perforated interior partitions to prevent erosion and pregnability of the acoustic fill.

C. Certification: The sound traps shall meet all applicable Codes for use and shall be so certified.

D. Manufacturer: As listed below or equal subject to sound trap performance schedule below.

<u>Type</u>	<u>Description</u>	<u>IAC</u>	<u>Vibron</u>	<u>Dynasonics</u>
L	Low Pressure Drop	LFL	VRS	LF
M	Medium Pressure Drop	LFM	VRS	PF
S	Standard Pressure Drop	LFS	VRS	SF
RDL	Round-Low Pressure	FCL	--	--
RDS	Round-High Pressure	FCS	--	--

E. Testing: Acoustical tests for each size and model type shall be in accordance with ASTM E477-73 or ASTM E477-80.

F. Sizing: As scheduled on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Required HVAC ambient noise criterion
 - a. The ambient noise levels resulting from HVAC equipment shall not exceed the noise criterion (NC) levels scheduled below.
 - b. The noise criterion scheduled herein have been utilized to determine the sizing of the sound traps and amount of acoustical lining of ductwork required to meet this criteria
 - c. Where field alterations are made to the design, main duct and branch duct velocities shall be such that the noise criteria scheduled herein is maintained.
2. All mechanical rooms, plenums, duct shafts and drywall duct enclosures shall be constructed airtight. This means that every precaution shall be taken to maintain construction completely airtight around a room so designated. Construction joints, duct penetrations, electrical boxes, frames, supports, cabinets, doors, access panels, fixtures, etc., all shall be built or installed in such a manner as to prevent sound transmission through any construction enclosing a room horizontally or vertically. Appropriate lintels, frames, blocking, escutcheons, grouting, gaskets, packing, caulking, taping, filling, etc., all shall be employed to prevent sound transmission. Refer to requirements of this Section for Resilient Penetrations.
3. Installation or use of vibration isolators must not cause any change of position of equipment or piping which would result in stresses in piping connections or misalignment of shafts or bearings. In order to meet this objective, equipment and piping shall be maintained in a rigid position during installation. The load shall not be transferred to the isolator until the installation is complete and under full operational load.

4. The Contractor shall not install any equipment, duct or piping which makes rigid contact with the "building" unless it is approved in this specification or by the Architect. "Building" includes, but is not limited to slabs, beams, columns, walls, partitions, ceilings, studs, ceiling framing and suspension systems.
5. Prior to installation, the Contractor shall bring to the Architect's attention any conflicts between trades which will result in unavoidable rigid contact at equipment, piping or ducts, as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
6. Prior to installation, the Contractor shall bring to the Architect's attention any discrepancies between the specifications and field conditions or changes required due to specific equipment selection. Corrective work necessitated by discrepancies after installation shall be at the Contractor's expense.
7. The Contractor shall obtain inspection and approval from the Architect of any installation to be covered or enclosed, prior to such closure.
8. The Contractor shall obtain written instructions from the vibration isolation manufacturer as to the proper installation and adjustment of vibration isolation devices; alternatively, the equipment may be installed by the vibration isolation manufacturer.
9. The Contractor shall correct, at no additional cost to the Owner, all installations which are deemed defective in workmanship or materials by the Architect.

B. Equipment isolators

1. Machines to be isolated shall be supported by a structural steel frame, Type RS, Type CI, Type BR, Type TS, Type RPA or Type RTB frames as described herein.
2. Brackets shall be provided as required to accommodate the isolator and provide a mechanical stop. The vertical position and size of the bracket shall be submitted by the isolator manufacturer.
3. Operating clearance between the bracket and the pad or floor shall be $3/8" + 1/16"$. The minimum operating clearance between the frame and the housekeeping pad or floor shall be 1" for rigid steel and 2" for concrete inertia base.
4. Frame shall be placed in position and the brackets supported temporarily by $3/8"$ shims prior to the installation of the machine or isolators.
5. Spring isolators shall be installed without raising the machine and frame assembly.
6. After the entire system installation is completed and under full operation load, the spring isolator shall be adjusted so that the load is transferred from the shims to the isolator. When all spring isolators are properly adjusted, the shims will be barely free and shall be removed. Thereafter, the shims will be used as a gauge to check that the $3/8"$ clearance is maintained so that the system will remain free of stress.
7. Installation of Type RTB shall be in strict conformance with the manufacturer's instructions.
8. Isolated outdoor equipment shall be provided with restraints for wind loading as recommended by isolator manufacturer.

C. Piping and Duct Resilient Support and Suspension

1. All piping is included under this Section of the Specifications except the following: fire standpipe and sprinkler piping, and natural or liquefied gas lines.
2. Pipes and ducts connected to vibrating equipment shall be resiliently supported or suspended for the required number of support points, or within the mechanical room, whichever distance is greater. The required number of support points are as follows: to 4" diameter, first 3 point of support; 4" to 8" diameter, first 4 points of support; 8"

diameter or greater, first 6 points of support. Refer to Part 2 for products. All connections to such equipment include flexible connections specified elsewhere in this Section.

3. Spring Hangers
 - a. Suspension Isolators shall be installed with the isolator hanger box as close as possible to the structure above. Such isolators shall be suspended from substantial structural members, not from slab diaphragms unless specifically approved.
 - b. Hanger rods shall be aligned to clear the hanger box.
4. Domestic water piping not connected to vibrating equipment shall be resiliently supported by the products listed under Part 2, in accordance with the manufacturer's instructions.

D. Flexible Duct Connections

1. Align sheet metal duct with fan or fan casing opening in all three dimensions prior to installation of flexible connection, so that the duct and fan openings nearly coincide and are almost equally spaced from one another all around. Do not install flexible connection until above requirements are met. Fans or fan casings and ducts shall be able to move 1" in any direction relative to each other without short-circuiting metal to metal or stretching taut the flexible connection.

E. Flexible Piping Connections

1. Flexible piping connections shall be installed within 10 feet of all vibrating equipment, or prior to penetration of the building, whichever is shorter, on all piping connected to such equipment. Flexible piping connections shall be located such that their length is at right angles to the principal direction of movement and thus such that the movement of the equipment does not alternately place the connection into tension and compression. Flexible piping connectors further more shall be installed in accordance with the manufacturer's recommended procedures and in lengths complying with ASHRAE 2003 HVAC Applications Handbook, Chapter 47, Table 43.

F. Resilient Penetrations

1. Penetrations included in this Section of the Specifications include all piping, ducts and conduit connected to vibrating equipment within 30 feet of such equipment.
2. Alternate A for round or rectangular penetrations.
 - a. Cut a clean opening in the penetrated construction, 3/4" to 1" larger in each cross-sectional dimension than the penetrating element. Provide lintels above, relief structure below and vertical framing between and to the sides, as required. Provide the above, escutcheon plates and such related construction as is necessary to make the penetrated structure as solid and massive near the penetrations as the surrounding construction.
 - b. Set the metal sleeve into the penetrated construction in an airtight manner around its outer periphery, using grout, dry packing, plaster or drywall compound full depth and all around - but only to a maximum width of 1/2" - or the requirements of the above paragraph shall not have been satisfied.
 - c. Pack annular opening between metal sleeve and penetrating element with glass or mineral fiber, full depth, all around to a firm degree of compaction. Leave a 1/2" deep annular opening free at each end of the metal sleeve; fill this fully with sealant.
3. Alternate B for round penetrations: Observe requirements above, except that use of sealant at sleeve ends is not required. In lieu of sealant, clamp factory-fabricated

sleeve assemblies specified in Part 2 tightly around penetrating elements, using built-in or field-supplied clamping devices. Apply clamping of sleeves to penetrating services before sealing of sleeves to penetrated constructions. Refer to manufacturer's instructions for installation of fire-rated rubber link systems.

G. Seismic Restraint Cables:

1. Metal cable type with approved end fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members or deck with aircraft cable and clamps as per SMACNA guidelines.

H. Mechanical Units

1. Install mechanical units by method indicated, complying with manufacturer's recommendations.

I. Diffuser, Grille, And Register

1. Install diffuser, grille and register by method indicated, complying with manufacturer's recommendations.

END OF SECTION 15240

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SECTION 15250 - MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15065 - Mechanical Supporting Devices

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. Provide insulating materials and accessories as required for mechanical systems as specified below.
- B. Insulating products delivered to construction site shall be labeled with manufacturer's name and description of materials.

1.04 DEFINITIONS

- A. Concealed areas, where indicated in this Section, shall apply to shafts, furred spaces and space above finished ceilings, inaccessible tunnels and crawl spaces. All other areas, including walk-through tunnels, shall be considered as exposed.
- B. Unless otherwise indicated, unit of thermal conductivity is (BTU in)/(hr ft² °F).

1.05 SUBMITTALS

- A. Shop drawings for each piping system for all pipe sizes, each ductwork system, and all equipment including, but not limited to, the following:
 1. Manufacturer's name.
 2. Schedule of insulating materials.
 3. Insulation material and thickness.
 4. Jacket.
 5. Adhesives.
 6. Fastening methods.
 7. Fitting materials.
 8. Intended use of each material.
 9. Manufacturer's data sheets indicating density, thermal characteristics, temperature ratings.
 10. Insulation installation details (manufacturer's installation instruction/details, Contractor's installation details, MICA plates where applicable.)
 11. All other appropriate data.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Insulation material shall be delivered to project site in original, unbroken factory packaging labeled with product designation and thickness. Shipment of materials from manufacturer to installation location shall be in weather-tight transportation. Protect insulation materials from moisture and

weather during storage and installation. Protect insulation material against long exposure to UV light from sun.

1.07 QUALITY ASSURANCE

- A. Installer qualifications: Three years minimum successful installation experience on projects with mechanical insulation similar in scope and nature to that required for the project.
- B. Requirements for energy conservation: All insulation shall be in accordance with ASHRAE Standard 90A.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Armaflex, Armstrong, Certain-Teed, Knauf, Manson, Nomaco, Owens-Corning or Schuller (Johns-Manville similar to product indicated except where product of manufacturers not listed above is specifically identified for special type of insulation.

2.02 MATERIALS

- A. Products used for or related to air conditioning and ventilating systems shall conform to NFPA 90A possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Unless otherwise indicated, all products, material itself or on a composite basis, shall meet ASTM E-84, UL 723 or NFPA 255 and shall not exceed 25 flame spread and 50 smoke developed.
- C. Insulation applied on stainless steel shall meet requirements of ASTM C795 and NRC 1.36.
- D. Where insulation materials and accessories are required to be painted, the material used shall be paintable.

2.03 INSULATION

- A. Insulation materials shall be fire retardant, moisture and mildew resistant, vermin proof and suitable to receive jackets, adhesives and coatings as indicated.
- B. Glass fiber insulation shall be of inert inorganic material, non-corrosive to mechanical surfaces.
- C. Insulating cement shall be Quick-Cote by PK Insulation MFG Co. or Ryder GP, with dry density of no more than 38 lb/ft³, thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.
- D. Filling and finishing cement shall be Super-Stik by PK Insulation MFG Co., or Ryder MW, with dry density of no more than 24 lb/ft³, thermal conductivity of 0.74 at 500°F mean temperature, and service temperature to 1900°F.
- E. Type F Insulation (Flexible Glass Fiber):
 - 1. Minimum density of 0.75 lb/ft³ with thermal conductivity of not more than 0.27 at 75°F mean temperature, and suitable for temperatures to 250°F. Owens Corning "All Service Duct Wrap", Johns Manville Microlite.

F. Type R Insulation (Rigid Glass Fiber):

1. Minimum nominal density of 3 lb/ft³, with thermal conductivity of not more than 0.23 at 75°F mean temperature. Minimum compressive strength at 10% deformation shall be 25 lb/ft².
2. Pipe insulation shall be suitable for temperatures to 850°F, Johns Manville Micro-Lok 850, Owens Corning Fiberglas ASJ/SSL-II.
3. Duct and equipment insulation shall be suitable for temperatures to 450°F, Johns Manville Spin-Glas Type 814, Owens Corning Type 703.
4. Pipe and tank wrap faced with specified jacket may be used for equipment and round ducts insulation, provided that it meets all insulation characteristics requirements stated above and maintains same R-value as specified.

G. Type A Insulation (Closed Cell Elastomeric Thermal Insulation):

1. Minimum nominal density of 6 lb/ft³, thermal conductivity not more than 0.27 at 75°F mean temperature, maximum water vapor transmission of 0.08 perm-inch and suitable for temperatures from -70°F to 220°F, Armstrong Armacell, or Nomaco (Rubatex).

2.04 JACKETS

A. Jacket puncture resistances shall be based on ASTM D-781 test methods. Vapor barrier permeance ratings shall be based on ASTM E-96 Procedure A.

B. Type P-1 Jackets:

1. Heavy-duty, fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be 0.0005" aluminum foil adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ-SSL", Johns Manville flame-safe "AP-T".

C. Type D-1 Jacket:

1. Heavy-duty, fire retardant material with glass fiber reinforcing. Jackets shall have neat, white Kraft finish or white vinyl finish suitable for painting, with beach puncture resistance of 50 units minimum. Vapor barrier shall be 0.0005" aluminum foil adhered to inner surface of jacket. Permeance shall not exceed 0.02 perm. Owens Corning "ASJ", Johns Manville "AP".

D. Type D-2 Jacket:

1. Glass fiber reinforced foil Kraft laminate with permeance not exceeding 0.02 perm and beach puncture resistance 25 units minimum. Owens Corning "FRK", Johns Manville "FSK".

2.05 ADHESIVES, MASTIC, COATINGS, SEALANTS, AND REINFORCING MATERIALS

A. Products shall be compatible with surfaces and materials on which they are applied, and shall be suitable for use at operating temperatures of systems to which they are applied.

B. Products shall be fire retardant, moisture resistant and mildew resistant and vermin proof.

C. Adhesives, mastic, sealants, and protective finishes shall be as recommended by insulation manufacturer for specified application.

D. Glass fiber fabric reinforcing shall be 10 x 10 or 20 x 10 mesh.

E. Wire mesh reinforcing shall be 22 ga, 1" galvanized.

F. Insulation cement shall be ANSI/ASTM C195, hydraulic setting mineral wool.

G. Finishing cement shall be ASTM C449.

- H. Butt joint and longitudinal joint adhesive for Type A insulation shall be Armstrong 520, Rubatex 373 or Manville 57.
- I. Weather-resistant protective finish for Type A insulation shall be equal to Armstrong WB Armaflex finish.

2.06 METAL BANDS AND WIRES

- A. Aluminum bands shall be 0.5" x 0.020" up to 48" diameter and 0.75" x 0.020" over 48" diameter.
- B. Stainless steel bands shall be 0.5" x 0.015" or 0.75" x 0.015".
- C. Stainless steel wires shall be 16 ga.

2.07 ACOUSTICAL BARRIER MATERIALS

- A. Acoustical barrier material shall be similar to Kinetics Model KNM-100B or EAR Lag-10. Barrier material to have acoustic ratings of STC-26, 1.0 lb/ft² weight, and minimum continuous operating range from -10 to 180°F.
- B. Minimum sound transmission loss at each octave band shall be as follows:

<u>Sound Transmission Loss (dB)</u>					
<u>Octave Band Center Frequency (Hz)</u>					
125	250	500	1000	2000	4000
15	16	21	26	33	38

PART 3 - EXECUTION

3.01 APPLICATION

- A. Provide insulation and jackets as indicated in the following schedule. The schedule applies to both exposed and concealed applications unless noted otherwise:

<u>Service</u>	<u>Jacket Type</u>	<u>Insulation Type</u>	<u>Piping System</u>				
			<u>Insulation Thickness According to Pipe Size</u>				
			3/4" and less	1" - 1-1/4"	1-1/2" - 3"	4" - 6"	8" and Larger
Heating Hot Water (141-200°F)	P-1	R	1"	1-1/2"	1-1/2"	1-1/2"	1-1/2"

Insulation thickness shall be the greater thickness specified for piping system or thickness specified above.

<u>Service</u>	<u>Ductwork/Equipment System</u>		
	<u>Jacket Type</u>	<u>Insulation Type</u>	<u>Insulation Thickness</u>
Supply Ducts Exposed	D-1	R	1-1/2"
Supply Ducts Concealed	D-2	F	1-1/2"

- B. Type F insulation with Type D-2 jacket may be used in lieu of Type R insulation with Type D-1 jacket for ductwork located 6 ft or higher above floor in mechanical equipment rooms. Horizontal ducts that are not completely 6 ft above floor shall be insulated with Type R insulation as specified for its entirety.

3.02 INSTALLATION - GENERAL

- A. All insulation installation methods shall be performed in accordance with the latest edition of National Commercial and Industrial Insulation Standards published by MICA (Midwest Insulation Contractors Association) and manufacturer's installation instructions, except as modified in this Section of specifications.
- B. Install products with good workmanship, with smooth and even surfaces. Use full-length factory-furnished material where possible. Do not use scrap pieces.
- C. Apply insulation only on clean, dry surfaces, after all rust and scale have been removed and testing of systems has been completed. Do not insulate any section of system that must be pressure tested until after it has been successfully tested. Any removal and reinstallation to correct system defects prior to end of guarantee period shall be accomplished at no expense to Owner.
- D. Install insulating materials with necessary joints and terminations, to permit easy access and removal of equipment sections where inspection, service or repair is required, and to allow for expansion.
- E. Where possible longitudinal joints in jackets shall face toward wall or ceiling.
- F. Apply insulation to each pipe or duct individually. Common insulation applied to adjacent pipes or ducts will not be accepted.
- G. Unless otherwise indicated, pipe and duct insulation shall be continuous through walls and floors.
- H. Where multiple layers of insulation are used, stagger and secure each layer with metal bands.
- I. Where penetrations occur through fire-rated walls, partitions, or floors, provide fire seal as specified in Section 15050 - Basic Mechanical Requirements and Section 15084 - Mechanical Systems Firestopping. Use calcium silicate inserts extending 2 inches beyond wall surface, at all piping penetrations through fire walls.
- J. Insulate the following systems for complete vapor barrier protection:
 - 1. All insulated ductwork
 - 2. All equipment with surface temperature below 65°F
- K. Apply Type A insulation for insulation and jackets requiring vapor barrier protection where specified insulations are cut for mounting sensors, control devices, parts of valves, devices or components which extend out from specified insulation to prevent condensation.

3.03 PIPING, VALVE AND FITTING INSULATION

- A. Apply insulation to pipe, unions, flanges, fittings, valves and piping specialties with butt joints and longitudinal seams closed tightly.
- B. Laps on factory-applied jackets shall be 2" minimum width firmly cemented with lap adhesive, or shall be pressure sealing type lap.
- C. Cover joints with factory furnished tape (3" minimum width) to match jacket. Cement firmly with lap adhesive.

- D. Secure insulation, except insulation covered with vinyl jackets, additionally with staples.
- E. Where staples are used, they shall be on 6" maximum centers. When used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.
- F. Built-up insulation for fittings and valves shall be made with sectional insulation, wrapped firmly to thickness of adjoining pipe insulation, and bound with jute twine, or built up with insulating cement, and finished to smooth hard surface, and covered with minimum of 9 oz per sq yd rewettable glass cloth similar to Clairmont Diplag 60.
- G. For valves and fittings requiring vapor barrier, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric after application of insulating cement. For valves and fittings not requiring vapor barrier, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulating cement. Apply coating in accordance with manufacturer's recommended procedure.
- H. For finishing of insulated pipe fittings and valves where surface temperature of insulation is not higher than 125°F, one piece PVC fitting covers, minimum thickness of 20 mil, may be used. Fitting covers located in mechanical rooms within 8 ft above floor shall be 30 mil thickness. Johns Manville Zeston 2000 PVC, PROTO Fitting Covers, or similar by other manufacturers listed. Where fitting and valve insulation requires vapor barrier, seal joints of PVC covers with vapor barrier adhesives. Insulation type, R-value and density of insulation used at fittings shall match those of adjacent piping. Install insulation at pipe fittings and valves completely prior to applying PVC covers.
- I. Where terminations of pipe insulation are required, insulation shall have tapered ends, built up and finished as specified for fittings.
- J. For pipes 1-1/2" and smaller, install specified pipe insulation and jacket continuous through hanger or support locations. Install insulation protection shields to protect insulation from compressing.
- K. For pipes 2" and larger, where manufactured pre-insulated pipe supports are used at hanger or support locations, extend insulation to insulated pipe supports. Where vapor barrier is required, this Contractor shall be responsible for continuity of vapor barrier at insulated pipe supports. Use 3" wide vapor barrier tape on hot and cold systems at pipe supports.
- L. For pre-insulated pipe supports and insulation protection shields, refer to Section 15065 - Mechanical Supporting Devices.
- M. Piping, fittings and valves not to be insulated:
 - 1. Control valves and balancing valves for heating terminal devices.
 - 2. Valves furnished with removable insulation/jacket.

3.04 DUCTWORK AND COMPONENTS

- A. Apply duct insulation evenly over duct surface. Unless otherwise indicated, insulation and jacket shall run continuously between duct and duct supports.
- B. For support points of rectangular or oval ducts supported by trapeze hangers, place weight-supporting insulation at bottom of duct over trapeze. Weight supporting insulation inserts shall be minimum 6" long with same thickness as insulation specified and shall be similar to HAMFAB H-block by ICA Inc. Follow manufacturer's recommendation for quantity of inserts.
- C. For support points of round ducts smaller than 16" diameter, weight-supporting insulation is not required for either rigid or flexible glass fiber insulation.

- D. For support points of round ducts 16" diameter and larger, place weight-supporting insulation between duct and strap or trapeze. Weight-supporting insulation shall be minimum 6" long with same thickness as insulation specified and shall be similar to HAMFAB H-block by ICA Inc.
- E. Flexible glass fiber insulation may be installed outside of support for round ducts 24" diameter or smaller, provided that vapor barrier integrity is maintained at rod penetration.
- F. Secure flexible glass fiber insulation (Type F) to underside of horizontal rectangular or oval ductwork 24" in width or greater and on vertical sides of horizontal and vertical ductwork with weld pin or mechanical fasteners not over 18" on center and within 3" of butt joint or edge.
- G. Secure rigid glass fiber insulation (Type R) to all sides of horizontal and vertical rectangular or oval ductwork with weld pin or mechanical fasteners. Install pins or fasteners as required to secure, but not less than 12" on center for underside and sides of ducts and 24" on center for top of ducts, and within 3" of butt joint or edge.
- H. Clip pins fastened to ductwork with adhesives are not allowed. Where weld pin fasteners are used, install them without damage to interior galvanized surface. Clip pins neatly back to each fastener.
- I. Where insulation is required for ductwork, provide insulation over entire ductwork system, including system components such as filters, mixing air chambers, sound attenuators, air measuring stations, reheat coils, etc.
- J. Where vapor barrier jackets are specified, pins shall be jacketed over with matching material. Where staples are used for systems requiring vapor barrier, cover lap and staples with finish coat of lagging adhesive.
- K. Insulation without factory jacket shall be cut and mitered to suit surface. Build up voids, seams and joints with insulating cement, cover with glass fabric as specified herein and finish to smooth surface.
- L. For other than factory-applied vapor barrier jackets, apply 2 coats of vapor barrier mastic with glass fiber reinforcing fabric, after application of insulating cement. For surfaces not requiring vapor barrier jackets, apply 2 coats of weatherproof mastic with glass fiber reinforcing fabric after application of insulation cement. Apply coating in accordance with manufacturer's recommended procedure.
- M. D-1 jackets:
 - 1. Butt together joints and seams firmly, cover with glass fiber fabric 4" minimum width and finish with 2 coats of vapor barrier mastic.
- N. D-2 jackets:
 - 1. Butt together joints and seams firmly and cover with 3" wide FSK tape.

END OF SECTION 15250

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SECTION 15511 - PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15065- Mechanical Supporting Devices.
- B. Section 15512 - Valves.

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. This Section includes pipe and pipe fitting specifications and installation requirements for heating system.
- B. Specification of an item in this or any other sections shall not relieve Contractor from providing all items, articles, materials, operations, methods, labor, equipment and incidentals necessary for a complete and functional system.
- C. Use only new material, free of defects, rust and scale, and guarantee for services intended.
- D. Use material meeting the latest revision of ASTM Specifications as listed in this Specification.
- E. Follow Local Codes if they require other types of pipe or joints.
- F. Use only long radius elbows having centerline radius of 1.5 pipe diameters unless otherwise indicated.
- G. Manufacturer, pressure class, size and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.
- H. Where size for a pipe segment is not indicated, the pipe segment size shall be equal to the largest pipe segment to which it is connected. Transition to smaller size shall occur on the side of fitting where smaller size is indicated.
- I. Unless otherwise indicated, fittings and accessories connected to pipe shall be of the same material as the pipe.
- J. Unless otherwise indicated, construct piping for highest pressures and temperatures in respective system in accordance with the latest revision of the applicable Sections of ASME Code for pressure piping, ASME B31 including the following:
 - 1. B31.9 Building Services Piping
- K. Non-metallic piping will be acceptable only for services indicated. It will not be acceptable in occupied spaces and ventilation plenum spaces.

1.04 SUBMITTALS

- A. Shop Drawings for each piping system for all pipe sizes including, but not limited to, the following:
 - 1. Name of system

2. Pipe; ASTM number, grade if known, type, wall thickness, material
3. Fittings; ASME number, grade if known, class, type, wall thickness, material
4. Joint type
5. Flanges; ASTM number, grade, class, type, material
6. Bolts and nuts; material
7. Thread joint sealants; material
8. Flange gaskets; material, rating
9. Unions; ASTM number, type, material, rating
10. Type of welding
11. Welding Quality Control Program
12. Test pressure and media
13. Pipe flushing procedures
14. Pipe cleaning method
15. All other appropriate data

B. Submit pipe certification as specified under Pipe Certification in this Section.

C. Submit required documents as specified under Pipe Welding in this Section.

1.05 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and construction debris from accumulating inside of pipe.
- B. Where possible, store materials inside and protect from weather. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.
- C. Before shipping, all carbon steel piping shall be free of rust and scale, and furnished with plastic end caps/plugs on each end of pipe.

PART 2 - PRODUCTS

2.01 HEATING HOT WATER

A. 2" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube.
2. Fittings: ASME B16.22, wrought copper solder joint.
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield.
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for line sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 150, cast copper alloy.
6. Use solder joints for valves and piping specialties in copper piping.
7. Propress Joint Option:
 - a. Contractor may use copper fittings as manufactured by Propress/Rigid.
 - b. Joints: Crimped, ProPress electro-hydraulic crimping tool.

- B. 2-1/2" and Larger:
 - 1. Pipe: ASTM A53, Grade B, Type E or S, standard weight, carbon steel.
 - 2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld.
 - 3. Flanges: Class 150. Refer to Unions and Flanges in this Section.
- C. Type F pipe may be used for 2-1/2" through 4" size.

2.02 PRESSURE GAUGES AND TAPPINGS

- A. Use pipe and pipe fittings as indicated for the system to which pressure gauge or tapping is connected. Use "Threadolets", "Sockolets" or tee fittings for tappings. Refer to Part 3 under General for use of "Threadolets" and "Sockolets".
- B. Gauge pipe shall be 1/4" unless otherwise indicated.
- C. Gauge pipe shall be 1/2" for high pressure steam (101 psig and over) systems.
- D. Brass tubing for chilled water service.

2.03 DIELECTRIC FLANGES AND FITTINGS

- A. Copper to Steel Pipe:
 - 1. 2" and Smaller: Use ball valves specified in Section 15512 for dielectric purpose.
 - 2. ASTM A197/ASME B16.3, equal to Stockham Figure 693-1/2, Watts Series 3000 or Epco Model FX dielectric unions with dielectric gasket, 250 psi at 210°F.
 - 3. 2-1/2" and Larger: Epco Model GWX or Watts dielectric flange fittings Series 3100/3110 with dielectric gasket, 175 psi at 210°F.

2.04 UNIONS

- A. Unions:
 - 1. 2" and Smaller: Malleable iron, ASME B16.39 with ground joint, bronze or brass to iron. Provide black malleable iron for carbon steel piping and galvanized malleable iron for galvanized steel piping. Unless otherwise specified, pressure class and joint type of union shall be equal to that specified for fittings of respective piping service. Minimum pressure class of unions shall be Class 250.

2.05 THREADED JOINT SEALANTS

- A. Paste type for brush application or cord type. Products shall be non-toxic, chemically inert, non-hardening, rated for -50 to 400°F and up to 10000 psi (liquids) and 2600 psi (gases), certified by UL, CSA, and NSF.
- B. Teflon tapes are not allowed.

PART 3 - EXECUTION

3.01 GENERAL

- A. Remove foreign materials before erection. Ream ends of piping to remove burrs.
- B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear

such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other Architectural details before installing piping.

- C. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.
- D. Mitered elbows, welded branch connections, notched tees and "orange peel" reducers are not allowed. Unless specifically indicated, reducing flanges and reducing bushings are not allowed. Reducing bushings may be used for air vents and instrumentation connections.
- E. Unless otherwise indicated, use fittings as specified in Part 2 of this Section for elbows, tees, reducers, etc.
- F. "Weldolets" with outlet size 2-1/2" and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch takeoff up to one half (1/2) diameter of main. Use "Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Materials of "Weldolets", "Threadolets" and "Sockolets" shall match material of piping.
- G. Install drains throughout systems to permit complete drainage of entire system.
- H. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.
- I. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide reducing fittings for valves smaller than pipe size.
- J. Make connections to all equipment installed by others where that equipment requires piping services indicated in this Section.

3.02 THREADED PIPE JOINTS

- A. Threads of pipe and fittings shall conform to ASME B1.20.1.
- B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.03 COPPER PIPE JOINTS

- A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.
- B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.

3.04 WATER SYSTEMS

- A. Pitch horizontal mains up at 1" per 40 ft in direction of flow. Install manual air vents at all high points where air may collect. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.
- B. Main branches and runouts to terminal equipment may be made at top, side or bottom of main provided that there are drain valves suitably located for complete system drainage and manual air vents are located as described above.
- C. Unless otherwise indicated, for upfeed risers, use top or top 45° connection to main and for downfeed risers use side or bottom 45° connection to main. If side or bottom 45° connection is not

practical and bottom connection to main must be used, provide line size Y strainer with shut-off valve at each side at branch connection.

- D. Use minimum of 3 elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems.
- E. Use eccentric fittings for changes in pipe sizes and for valves smaller than pipe sizes, in horizontal lines, with fittings installed for proper air venting (top of pipe straight). Concentric fittings may be used for changes in pipe sizes and for valves smaller than pipe sizes in vertical lines..

3.05 DIELECTRIC FITTINGS

- A. Install dielectric flanges or fittings in main and branch piping of water systems at each point where copper to steel pipe connection occurs.
- B. Use dielectric waterways. Dielectric unions are not allowed.
- C. Concealed dielectric fittings are not allowed.

3.06 UNIONS AND FLANGES

- A. Unions are not required on copper piping with soldered joints for 1/2" and 3/4" line sizes. Unions are required for line sizes 1" and larger.
- B. Install union or flange at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair or replacement. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
- C. Concealed unions or flanges are not allowed.

END OF SECTION 15511

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SECTION 15512 - VALVES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15250 - Mechanical Systems Insulation

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SUBMITTALS

- A. Shop Drawings for each system for all sizes including, but not limited to, the following:
 1. Manufacturer's name.
 2. Type.
 3. Model number.
 4. Materials of construction.
 5. Temperature/pressure ratings.
 6. Manufacturer's data sheets clearly cross-referenced.
 7. All other appropriate data.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, Kitz or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.
- B. Other valves: acceptable manufacturers and Figure Number listed under each item.

2.02 WATER SYSTEM VALVES

- A. General:
 1. Valves 2" and smaller, in steel piping shall have threaded ends.
 2. Valves 2" and smaller, in copper piping shall have solder ends.
 3. Provide valve neck extensions with sufficient length to allow for insulation where insulation is specified.
- B. Ball Valves:
 1. 2" and Smaller: ASTM B584 bronze body, stainless steel ball, full port, Teflon seat rings, blowout-proof stem, two-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T-585-70, Apollo No. 77, Watts, Milwaukee, Hammond, Kitz or Anvil.
- C. Globe Valves:
 1. 2" and Smaller: ASTM B62 bronze body, renewable TFE disc, union or screw-over bonnet, malleable iron hand wheel, Class 150 (300 psi WOG), conforming to MSS SP-80, Nibco Figure T-235Y.

2. 2-1/2" and Larger: iron body, bronze mounted OS&Y, flanged, renewable bronze seat and disc, Class 125 (200 psi WOG), Nibco Figure F-718.
- D. Shut-Off Valves:
1. 2" and Smaller: ball valves as specified in this Section.
 2. 2-1/2" and Larger: butterfly valves as specified in this Section.
- E. Balancing Valves:
1. 2" and Smaller: calibrated balancing valves:
 - a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour and Anderson Sirius 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by Flow Design Inc., Presco, Gerand, or Taco. Bronze or brass body, 125 psig WP or 400 psi WOG at maximum temperature of 250°F. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
 - b. Valves shall measure down to 0.3 gpm with accuracy of $\pm 3\%$.
 - c. Valves shall be leak-tight at full rated working pressure.
 - d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.
 2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson STAF-SG/STAG, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi working pressure, 250°F operating temperature. Fixed orifice with ball valve type as manufactured by FDI, Presco or Gerand, Class 150 flange, 250 psi working pressure, 250°F operating temperature will be acceptable up to 4" size.
 3. Contractor shall furnish meter for calibration and shall retain meter after final calibration.
- F. Drain Valves:
1. Ball valve as specified above with hose-end connection. Provide 3/4" minimum drain valve for piping larger than 1/2", except strainer blowdown valves shall be blowdown connection size. Provide 1/2" drain valve for 1/2" piping.

PART 3 - EXECUTION

3.01 GENERAL

- A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.
- B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.
- C. Install control valves furnished under Control Systems. Provide increaser and decreaser fittings as required.
- D. Refer to Section 15511, Part 3, for reducing fittings requirement for valves smaller than pipe size.
- E. Provide chain operators for manually operated valves 4" and larger, located more than 8 ft above equipment room floor.

3.02 SHUT-OFF VALVES

- A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.
- B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.03 BALANCING VALVES

- A. Provide balancing valves where indicated on drawings and as required for complete balancing of water systems.
- B. Provide straight inlet and outlet pipe length in accordance with manufacturer's recommendation.
- C. For buildings with multiple stories, provide balancing valve in return line at riser take-offs at each floor. Provide shut off valve in supply line at each riser take-off.

3.04 DRAIN VALVES

- A. Provide drain valves at all low points of piping systems for complete drainage of systems.

END OF SECTION 15512

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SECTION 15830 - HEATING AND COOLING TERMINAL DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15055 - Motors
- B. Section 15250 – Mechanical Systems Insulation
- C. Section 15511 – Pipe and Pipe Fittings
- D. Section 15512 – Valves

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SUBMITTALS

- A. Shop Drawings for all items in this Section including, but not limited to, the following:
 - 1. Manufacturer's name and model number.
 - 2. Identification as referenced in the Documents.
 - 3. Capacities/ratings.
 - 4. Materials of construction.
 - 5. Dimensions and weights.
 - 6. Manufacturer's installation instructions.
 - 7. All other appropriate data.

1.04 REFERENCE STANDARDS AND DESIGN CRITERIA

- A. Duct Reheat Coils: Ratings shall be certified in accordance with ARI Standard 410.
- B. Units including electrical work shall be UL Listed.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in manufacturer's original protective packaging. Store materials in area protected from weather, moisture, dirt or dust. Handle material to prevent damage, paint chipping or deformation.

1.06 QUALITY ASSURANCE

- A. Radiation capacities shall be in accordance with HYDI Standard for "Testing and Rating Code for Finned-Tube Commercial Radiation".

1.07 QUALIFICATION AND GUARANTEE

- A. Contractor shall install system in accordance with manufacturer's recommendation, complete, and to the satisfaction of Architect and/or Engineer.

- B. Guarantee radiant ceiling panel system to perform as specified and to function without objectionable noise generated from thermal expansion/contraction or hydronic resonance to Architect's and/or Engineer's satisfaction and acceptance.

PART 2 - PRODUCTS

2.01 DUCT REHEAT COILS (HOT WATER)

- A. Manufacturers: Carrier, Trane, McQuay, Marlo, Temtrol, Dunham-Busch, or Heatcraft.
- B. Coils shall be constructed of 1/2" or 5/8" OD copper tubes with aluminum fins suitable for minimum working pressure to 200 psig and temperatures to 220°F.
- C. Coils having steel nipples for connection are not allowed.
- D. Coil fins shall be continuous serpentine or plate fin type.
- E. Coil headers shall be cast iron with tubes expanded into headers or heavy seamless copper with all tubes brazed to header.
- F. Casing shall have G90 galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.
- G. Coil frame shall be suitable for drive slip or flange and gasket connection to ductwork.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units as indicated on drawings, and according to manufacturer's installation instructions.
- B. Install branch piping to each unit with minimum of 3 elbows to allow for expansion and contraction.

3.02 DUCT REHEAT COILS

- A. Comb out fins when bent or crushed before enclosing coils in ductwork. Clean dust and debris from each coil to ensure its cleanliness.
- B. Seal or gasket coil connection to ductwork to meet maximum allowable leakage rate specified in Section 15900 - Ductwork, Part 3.
- C. Unless otherwise specified, connect piping to coils with multiple rows for counter-flow arrangement.

END OF SECTION 15830

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SECTION 15850 - FANS

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15055 - Motors
- B. Section 15060 - Variable Frequency Drive (VFD) System
- C. Section 15240 – Mechanical Noise and Vibration Control

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number.
 - 2. Identification as referenced in the Documents.
 - 3. Capacities/ratings.
 - 4. Fan curves.
 - 5. Materials of construction.
 - 6. Sound power levels.
 - 7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives.
 - 8. Wheel type, diameter, rpm, tip speed.
 - 9. Required fan horsepower including drive losses.
 - 10. Motor data (refer to Section 15055 - Motors).
 - 11. Vibration isolators furnished with fans.
 - 12. Dimensions and weights.
 - 13. Special coatings where applicable.
 - 14. Manufacturer's installation instructions.
 - 15. All other appropriate data.
- B. Fan curves shall include series of curves indicating relationship of flow rate (cfm) to static or total pressure for various fan speeds, brake horsepower curves, and selection range (surge curves, maximum rpm, etc).
- C. Indicate performance data, based on both design air quantity and 110% of design air quantity.
- D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and horsepower.

1.04 DESIGN CRITERIA

- A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.

- B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified. Motors for V-belt drives shall be furnished with adjustable rails or bases.
- C. Each fan wheel shall be statically and dynamically balanced to grade G6.3 per ANSI S2.19. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-96 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.
- D. For fans furnished with 5 HP or larger HP motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan, scheduled rpm shall not exceed the following values when fan is rigidly mounted:
 - 1. Belt Drive (except Vane Axial).....0.15 in/sec peak velocity
 - 2. Belt Drive Vane Axial.....0.08 in/sec peak velocity
 - 3. Direct Drive.....0.08 in/sec peak velocity
 - 4. Written records of run test and vibration test shall be available upon request.
- E. Furnish fans specified with V-belt drives with either variable-pitch or fixed-pitch sheaves for drives 3 HP and smaller and fixed-pitch sheaves for drives 5 HP and larger. Select variable pitch sheaves to drive fan at such speed as to produce specified capacity at approximate midpoint of sheave adjustment.
- F. When fixed-pitch sheaves are furnished, system air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.
- G. Select each fan to operate at single stable operating point as predicted by fan curve. Fans having 2 potential operating points on fan curves are not acceptable.
- H. Unless otherwise indicated, V-belt drives shall be selected for 150% of motor nameplate horsepower.
- I. Provide OSHA Compliant belt and shaft guards for belt driven fans. Provide speed test openings at shaft locations. Paint guards bright yellow.
- J. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.
- K. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. Motor furnished with fan shall not operate into motor service factor or class limit in any of these cases.
- L. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.
- M. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of change and system effect factor calculations indicating increased static pressure requirements as described in AMCA Publication 201. This Contractor shall be responsible for costs associated with any motor, drive, and/or wiring changes required as a result of duct configuration changes at fan.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of specified fans with characteristics, sizes, and capacities required, whose specified fan has been in satisfactory use in similar service for not less than 3 years.
- B. Codes and Standards: Comply with the following:
 - 1. AMCA Compliance: Provide fans which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Ratings Seal.
 - 2. NEMA Compliance: Provide motors and electrical accessories complying with NEMA standards.
 - 3. UL Compliance: Provide power ventilators which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".

PART 2 - PRODUCTS

2.01 TUBULAR MIXED FLOW FANS

- A. Manufacturers: Acme, Barry, Chicago Blower, Cook, New York Blower, Greenheck or Twin City.
- B. Housings: Heavy gauge steel with welded fabrication, adequate reinforcing to prevent housing distortion, fully streamlined inlet cones, multiple straightening vanes following fan wheel to redirect air flow to minimize noise and reduce turbulence and flanged inlet and outlet. Fan housings to be designed to promote straight line, air flow from entrance to discharge.
- C. Wheels: Non-overloading airfoil blades welded to wheel cones unless otherwise indicated.
- D. Bearings: Heavy duty self-aligning, grease packed, cast iron, pillow block type with grease seal, furnished with external grease fittings, selected for minimum life (ABMA L-10) of not less than 40,000 hrs operation at maximum cataloged operating speed. Drives and bearings to be contained within belt tube, isolating drives completely away from airstream.
- E. Painting: Fan parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to exterior surfaces.
- F. Motor Mounting: Fan motor to be mounted on adjustable platform appropriate to fan arrangement.
- G. Flow sensor: Manufacturer provided, factory installed non-invasive flow measurement probes and connective nylon tubing. Manufacturer to provide data necessary for calculation of flow and calibration of controls.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and cap discharge of drain.
- B. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 15240 – Mechanical Noise and Vibration Control.

C. All fans shall be installed plumb and level by technicians trained accordingly.

END OF SECTION 15850

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SECTION 15852 - SPECIAL EXHAUST SYSTEMS

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15050 – General Mechanical Requirements
- B. Section 15240 – Mechanical Noise and Vibration Control
- C. Section 15850 – Fans
- D. Section 15900 – Ductwork
- E. Section 15910 - Ductwork Specialties
- F. Section 15991 – Air Systems Test Adjust Balance

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

- A. "Industrial Ventilation, a manual of Recommended Practice" published by American Conference of Governmental Industrial Hygienists (ACGIH)
- B. National Fire Protection Association (NFPA)
- C. American Society for Testing and Materials (ASTM)
- D. American National Standards Institute (ANSI)
- E. American Industrial Hygiene Association (AIHA)
- F. Center for Disease Control (CDC)
- G. The National Institute of Health (NIH)
- H. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

1.04 SUBMITTALS

- A. Include schedule of each duct system for all sizes. Each duct system schedule shall include, but not be limited to, the following:
 - 1. Name of Contractor/Manufacturer fabricating each duct system.
 - 2. Material and gauge.
 - 3. Pressure class.
 - 4. Transverse joint length and reinforcement.
 - 5. Intermediate reinforcement.
 - 6. Joint construction.
 - 7. Fitting construction.
 - 8. Support methods.

9. Structural attachments.
 10. Sealant and gasket.
 11. Sheet metal specialties.
- B. Capture Devices.
- C. Portable Hoods for Welding Exhaust.

PART 2 - PRODUCTS

2.01 CAPTURE DEVICES

- A. Provide hoods as shown on drawings and as detailed. Devices shall be constructed of galvanized steel 2 gauges heavier than connecting ductwork with galvanized angle iron reinforcement where required or plexiglass as indicated on the drawings.
- B. Support hoods independent of ductwork using threaded rod, strap hangers, or angle iron. Use SMACNA Standards for ductwork for hanger types and spacing.
- C. Hood edges shall have flanges turned in or out with hemmed edges. Hoods shall be free of sharp edges or burrs.

2.02 WELDING EXHAUST SNORKELS

- A. Basis of design: Air Flow Systems EZ Arm with Boom Options
- B. Approved alternate manufacturers: Nederman NEX-HD, Donaldson-Torit
 1. Alternates must meet same length, hood material and static pressure drop performance of Air Flow EZ Arm.
- C. Air Flow Systems E-Z Arm Model 7E10 or 7E07 (per drawings), high flow extractor arm. Unit is furnished complete with the following:
 1. 7" diameter x 10' long or 7' long articulated arm assembly, with external pawl and sprocket at the mid-arm support and an external spring counter balance joint at the upper base for maximum strength and maneuverability.
 2. Spun aluminum hood with black powder coat finish, measuring 13" in diameter Hood has a 160° movement. Hood has a 360°, rounded perimeter flange to maximize fume capture efficiency.
 3. Rag guard, hood inlet screen.
 4. Halogen light kit with 65 watt, 12 volt light assembly, with transformer, 1 or 3 phase. Switch for light on hood.
 - a. All low voltage wiring and switch shall be factory provided and wired.
 5. Durable round duct constructed of 21 ga. aluminum is light weight and rugged, powder coated inside and out. Use of hard duct, with flex hose only at joints, minimizes arm pressure loss. Flex hose is Hi-Flow spiral wire reinforced, with superior strength and resistance to sparks.
 6. Wall mount bracket.
 7. Boom arm extensions 5' in' lengths to extend the reach of the 7E10 to 15'. Boom kit to include: Boom, boom wall mount bracket, (1) tube kit, (1) 6.75" x 36" flex hose and (1) 8" transition. See plans for location of boom arms.

2.03 GALVANIZED STEEL SHEET

- A. First quality, cold rolled, open hearth soft steel sheet capable of double seaming without fracture. Galvanized coating shall be 1.25 oz/ft² equivalent to G90 galvanizing according to ASTM A525 and ASTM A90.

2.04 UNCOATED BLACK STEEL SHEET

- A. First quality, hot or cold rolled, open hearth soft steel sheet capable of welding or double seaming without fracture. Sheets shall be ASTM A-569. Black steel not covered with other materials, shall be painted with 2 coats of primer. Plates shall be ASTM A336. Structural shapes shall be ASTM A36.

2.05 ALUMINUM SHEET

- A. First quality aluminum alloy 3003H-14 capable of double seaming without fracture.

2.06 STAINLESS STEEL SHEET

- A. First quality stainless steel sheet, cold rolled, annealed, pickled, ASTM-A240, Type 304, Finish No. 2B for concealed work and Finish No. 4 for exposed work.

2.07 POLYVINYL CHLORIDE COATED STEEL SHEET

- A. Hot-dipped galvanized steel sheet coated with prime coat and polyvinyl chloride film on both sides, minimum 4 mils on side exposed to the contaminant and minimum 1 mil on the uncontaminated side. Material shall be UL 181 Listed as Class 1 Air Duct.
- B. Use suitable duct sealer in accordance with manufacturer's recommendations.

2.08 SINGLE WALL MANUFACTURED DUCTWORK

- A. Manufacturers: Ajax, Semco or United McGill.
- B. Duct shall be machine formed round and/or flat oval spiral lock seam duct constructed of galvanized steel as specified above. Use fittings as indicated on drawings and as required in accordance with manufacturer's published data.
- C. Internal bracing will not be accepted.

2.09 DUCT SEALANT

- A. Use sealant as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. Hardcast, United McGill, Mon-Eco Industries, HB Fuller/Foster, or approved equal.

2.10 GASKETS

- A. Use butyl tape similar to Ventfabrics Ventlok No. 797 or 799 in flanged joints.

2.11 BLAST GATES

- A. Provide factory made blast gates equal to Ajax, Semco, or United McGill.
- B. Units shall be fabricated with knife type blade. Design shall be such that all edges are out of air stream when damper is closed. Provide position locking device.
- C. Units shall be designed with a positive seal. Knife blade shall be totally enclosed. Provide sealing nut and gasket for positioning arm. Unit shall be equal to United McGill Model SRFIBGP.

2.12 FLEXIBLE DUCT

- A. Provide non-insulated flexible duct for runouts shown on drawings. Lengths shall not exceed 5'0" unless otherwise noted. Material shall be Clevepak Corporation, Wiremold, Flexmaster, or Flexaust.
- B. For Class 1, low pressure applications, use aluminum/stainless steel, spiral wound into tube and spiral corrugated. Construction shall be triple mechanical lock to form continuous secure air tight joint. Product shall be equal to Flexmaster Triple Lock.
- C. For general purpose, Class 1 duty, negative pressure up to 10" WG, use vinyl coated nylon for cover and liner, enclosed helix, smooth bore, highly visible scuff strip, flexible, non-supporting type. Equal to Wiremold Model TD-HS. Not recommended for acids, bases, or solvents.
- D. For use with solvents, Class 1 duty, negative pressure up to 2" WG, use flexible, polyethylene hose, corrugated, self-supporting construction. Equal to Wiremold Model VAC-U-FLEX CPM.
- E. For heavy duty, Class 2 duty, negative pressure up to 28" WG, use flexible EVA hose, interlocked, self-supporting (non-wire helix), crush resistant. Equal to Wiremold Model VAC-U-FLEX CBS.

PART 3 - EXECUTION

3.01 MATERIAL HANDLING SYSTEMS

- A. Ductwork between capture devices and collection devices shall be specified as to its class, static pressure, and material. Use round duct except where oval or rectangular duct shown on drawings. Round duct and its supports shall conform to SMACNA Manual for "Round Industrial Duct Construction Standards". Rectangular duct and its supports shall conform to SMACNA Manual for "Rectangular Industrial Duct Construction Standards".
- B. Round ductwork shall be constructed with longitudinal seams.
- C. Spiral wound duct may be used in lieu of longitudinal seams for Class 1 and Class 2 ductwork within material and pressure limitations set by manufacturer. Lighter gauges may be used if ductwork meets pressure classification required.
- D. Girth joints except welded or flanged shall be made with inner lap in direction of flow of 1-1/2" and riveted or spot welded on 4-1/2" centers - with not less than four rivets for any such lap joint.
- E. Elbows and bends shall be minimum of 2 ga heavier than straight lengths of equal diameter and have centerline radius of at least 1-1/2 and preferably 2 times the pipe diameter.
- F. Elbows of 90° shall be five-piece construction for round duct up to 6" WG and seven-piece for larger diameters. Bends of less than 90° shall have proportional number of pieces. Prefabricated die stamped elbows of smooth construction may be used up to 8" diameter.
- G. All branches shall enter main at large end of transition at angle not to exceed 45° with 30° preferred. Connections shall be to top or side of main with no 2 branches entering at opposite side.
- H. Transitions in mains and sub-mains shall be tapered. Taper shall be at least 5 units long for each one unit change in diameter.
- I. Access doors shall be slide or split sleeve type and shall be provided in horizontal runs of ducts carrying dust-laden air and, especially, near elbows, junctions and vertical runs. The spacing of access doors should not exceed 12 ft for ducts of 12" diameter and less but may be greater for larger duct sizes.

- J. Provide dead-end caps within 6" from last branch of all mains and submains.
- K. Support ducts sufficiently to place no load on connecting equipment and to carry weight of system if plugged with material. Maximum supporting interval 12 ft for 8" or smaller ducts, 20 ft interval for larger ducts.
- L. Provide 6" minimum clearance between ducts and ceiling, wall or floors.
- M. Where blast gates are used for adjustment of system, place near connection of branch to main. Provide means of locking after adjustments have been made. Butterfly-type dampers are not to be allowed.
- N. Connect duct to fan inlet with split sleeve drawband at least one pipe diameter long, but not less than 12".
- O. Field coordinate installation of paint spray booth exhaust duct's access openings with sprinkler contractor. Access openings are to be used for inspection of sprinklers.

3.02 CAPTURE DEVICES

- A. Install capture devices as shown or as directed by Owner for Owner Furnished Equipment.

3.03 WOOD DUST COLLECTORS

- A. Install as per manufacturer's recommendations. Provide clean filter media and set controls up for anticipated use. Provide all necessary interlocking wiring.

3.04 WOOD SAWDUST SYSTEMS

- A. Ductwork shall be galvanized steel, Class 2, 10" WG, negative pressure design.
- B. Install capture devices for proper dust removal from each piece of equipment and floor sweeps as shown on drawings and/or as detailed.
- C. Provide blast gates on all branch lines except floor sweeps, which have integral damper and for planers.
- D. Heavy duty, Class 2, flexible duct may be used for the last five feet before the capture device.

3.05 GRINDING, BUFFING AND POLISHING SYSTEMS

- A. Ductwork shall be galvanized steel, Class 2, 10" WG negative pressure design.
- B. Install capture devices for proper dust removal from each wheel and as shown on drawing and/or as detailed.
- C. Provide blast gates on each branch duct.
- D. Heavy duty, Class 2, flexible duct may be used for last feet before the capture device.

3.06 FUME EXHAUST DUCT CONSTRUCTION

- A. General:
 - 1. Construct elbows with centerline radius to width or diameter ratio of at least 1.5 and 45° lateral branch take-offs from mains.
- B. Internal bracing or tie rods are not allowed.

- C. Duct pressure class shall be as follows:
 - 1. Negative 10 inches WG for all fume exhaust ductwork.
- D. Stainless Steel Ducts:
 - 1. Use 18 ga or heavier Type 304 stainless steel sheet with all joints and seams butt-welded airtight.
 - 2. Use longitudinal seam construction with seam at top on horizontal runs. Spiral seams are not allowed on round duct.
 - 3. Grind and polish smooth all interior joints.

3.07 FUME EXHAUST STACKS

- A. Construct stacks of no lighter than 10 ga, galvanized steel sheet. Use flanged joints as required.
- B. Construct stacks of sufficient strength so that top of stack will not deflect more than 1/2" under horizontal wind pressure of 40 psf over surface area of stack.
- C. Provide 3 guy wires connected to stack with stainless steel ring located 1/3 of stack height from top of stack anchored back to building structure. Stacks may be self supporting design without guy wires.

3.08 FUME EXHAUST FAN SHUTOFF DAMPERS

- A. Install in the fan suction ductwork for exhaust fans where indicated on the drawings and in accordance with the manufacturer's instructions.

3.09 WELDING EXHAUST SYSTEMS

- A. Ductwork shall be galvanized steel, Class 2, 10" WG negative pressure design.
- B. Install welding booths and other capture devices as shown on drawings and as detailed.
- C. Provide manual balancing dampers as per Section 15910 - Ductwork Specialties, in each branch duct.
- D. Heavy duty, Class 2, flexible duct may be used for the last five feet before the capture device.

3.10 CLEANING

- A. Protect ductwork during construction against entry of foreign matter.

3.11 LEAKAGE TEST

- A. Test ductwork in accordance with test method described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual, except the test pressure shall be equal to the duct pressure class specified.
- B. Locate leak sources, repair and retest when necessary.
- C. Leakage rate shall not exceed more than 1% of system air quantity. Welded ductwork shall have no leakage.
- D. Fume Hood Exhaust:
 - 1. Testing, inspecting and certifying hazardous exhaust systems, fume hoods and chemical storage cabinets will be performed by UCB Facilities Management Department and Environmental Health and Safety.

2. Testing procedures shall conform to UCB Standards and ANSI/ASHRAE 110-1995 Standard: "Method of Testing Performance of Laboratory Fume Hoods". Calibrated air velocity measuring devices as specified in Chapter 9 of the ACGIH – "Industrial Ventilation, a Manual of Recommended Practice" shall be used in testing procedures. EH&S will use a calibrated, direct reading air velocity measuring device for certification and inspection purposes. If a meter has not been calibrated at, or adjusted for 5,000 feet above sea level, a density correction factor must be used when measuring air velocities. EH&S shall certify that the fume hood is in safe operating condition and meets applicable UCB Standards.

END OF SECTION 15852

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SECTION 15900 - DUCTWORK

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15065 - Mechanical Supporting Devices
- B. Section 15240 – Mechanical Noise and Vibration Control
- C. Section 15250 - Mechanical Systems Insulation
- D. Section 15910 - Ductwork Specialties
- E. Section 15991 - Air Systems Test Adjust Balance

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SUBMITTALS

- A. For each duct system, submit schedule utilizing reinforcement tables from SMACNA HVAC Duct Construction Standards where applicable. Each duct system schedule shall include, but not be limited to, the following:
 - 1. Name of Contractor/manufacturer fabricating each duct system.
 - 2. Material and gauge.
 - 3. Pressure class.
 - 4. Transverse joint type and length and reinforcement rigidity class with designated joint T number or proprietary duct connection if utilized for each system.
 - 5. Certified test results of proprietary joint products, if used, tested in accordance with SMACNA procedures.
 - 6. Intermediate reinforcement spacing and rigidity class with metal angle dimensions and gauge.
 - 7. Type of longitudinal seam.
 - 8. Fitting construction details.
 - 9. Support methods including spacing, upper attachments, and lower attachments.
 - 10. Sealant and gasket.
 - 11. Sealing class.
- B. Duct leakage testing methods, apparatus and apparatus certification signifying meter is in conformance with ASME Requirements for testing meters.
- C. Duct liner including data on thermal conductivity, air friction correction factor, and temperature and velocity limitation.
- D. Submit the following information for welded sheet metal ductwork:
 - 1. Welding Procedure Specification (WPS) for welded joints. Form to be similar to ANSI/AWS D9.1-90 Code, Appendix "D".
 - 2. Procedure Qualification Record (PQR) for each WPS. Form to be similar to ANSI/AWS D9.1-90 Code, Appendix "E".

3. Welder Qualification Test Record (satisfactory performance) for each field or shop welder. Form similar to ANSI/AWS D9.1-90 Code, Appendix "F".

1.04 DESCRIPTION

- A. Furnish and erect ductwork free of objectionable vibration, chatter, and pulsations. Verify dimensions at site, making field measurements and drawings necessary for fabrication and erection.
- B. Duct sizes indicated are net inside dimensions.
- C. Where size for a duct segment is not indicated, the duct segment size shall be equal to the largest duct segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

1.05 DESIGN CRITERIA

- A. All products shall conform to NFPA 90A, and shall possess flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Unless otherwise indicated, construct all ductwork of galvanized sheet metal for pressure class not less than +2" WG for positive pressure ductwork and not less than -2" WG for negative pressure ductwork.
- C. Ductwork shall comply with Local, State and Federal requirements.
- D. Unless otherwise indicated, construct ductwork to meet functional criteria defined in Chapter VII of SMACNA HVAC Duct Construction Standards, Metal and Flexible, 1995 and other SMACNA Duct Construction Standards where applicable.
- E. Unless otherwise indicated, pressure class for VAV system supply ductwork between supply fan discharge and air terminal device inlet shall be not less than 6" WG pressure class.
- F. Unless otherwise indicated, pressure class for welding exhaust ductwork between exhaust fan inlet and exhaust snorkel inlet or capture device outlet shall be designed for 10" WG negative pressure.
- G. Duct transverse joints and reinforcement material, including angle ring flanges and stiffeners, shall be of same material as duct.
- H. Except as modified in this Section of specifications, use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA Publications:
 1. HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005, for rectangular and round ductwork up to positive 10" WG and negative 10" WG and flat oval ductwork up to positive 10" WG.
 - a. Internal tie rods or bracing are not allowed for duct 36" and smaller for high pressure ductwork. Tie rods shall be 1/2" or 3/4" galvanized steel conduits with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod.
 - b. Internal tie rods are not allowed for ductwork in chase and other non-accessible spaces.
 2. Round Industrial Duct Construction Standards, 2nd Printing 1999.
 3. Round Industrial Duct Construction Standards, 2nd Edition, September, 1999.
 4. Rectangular Industrial Duct Construction Standards, 8th Printing, 1997.
 5. Accepted Industry Practice for Industrial Duct Construction, 1st Edition, 4th Printing, 1988, for round ductwork -4" to -20" WG (Table 1-A) and for rectangular ductwork -4" to -20" WG (Table 2-A).

PART 2 - PRODUCTS

2.01 GALVANIZED STEEL SHEET

- A. First quality, Lock Former Quality (LFQ), cold rolled, open hearth soft steel sheet capable of double seaming without fracture, ASTM A924 or ASTM A653. Galvanized coating shall be G90.
- B. Use G90 Galvaneal or Zincgrip where painting is specified.
- C. Welding exhaust duct shall be galvanized steel, Class 2.

2.02 FLEXIBLE DUCT

- A. Manufacturers: Thermaflex, Casco, or Flexmaster, similar to Thermaflex Model M-KC or M-KE.
- B. Factory fabricated, UL Listed under UL-181 as Class 1 Duct, meeting requirements of NFPA 90A with flame spread of 25 or less and smoke developed rating of 50 or under.
- C. Flexible duct shall be suitable for:
 - 1. Operating Temperature:-20 to 250°F
 - 2. Operating Pressure:+10" WG (4-12" ID)
 - +6" WG (14-16" ID)
 - +4" WG (18-20" ID)
 - 1" WG (4-12" ID)
 - 0.5" WG (14-20" ID)
 - 3. Velocity: 5000 fpm
- D. Unless otherwise indicated, duct shall be nonmetallic insulated type composed of polyester film, polyethylene film, nylon film or coated woven fiberglass liner bonded permanently to corrosion resistant coated steel wire helix.
- E. Insulation shall be minimum 1" fiberglass insulation blanket with maximum thermal conductance of 0.23 K at 75°F. Vapor barrier jacket shall be aluminum foil reinforced, polyethylene, or metalized polyester film with minimum perm rating of 0.05 perm.
- F. Insulation material shall not be exposed to air stream.

2.03 MANUFACTURED ROUND OR FLAT OVAL DUCTWORK (POSITIVE PRESSURE)

- A. Single Wall:
 - 1. Manufacturers: Ajax, Lindab, Semco or United McGill, equal to United McGill Uni-Seal duct and fittings suitable to positive 10" WG.
 - 2. Ducts shall be machine formed round and/or flat oval as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Longitudinal seam construction may be used for ductwork over 80" diameter with minimum 16 ga. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
 - 3. Unless otherwise indicated, connection shall be slip type with minimum 2" insertion length or flanged joint in accordance with manufacturer's recommendations. When flange joints are required, use Van Stone Angle Rings welded to duct.
 - 4. Internal bracing is not allowed.

2.04 MANUFACTURED ROUND DUCTWORK (NEGATIVE PRESSURE)

- A. Manufacturers: United McGill Industrial duct and fittings. Semco and Lindab are acceptable manufacturers, provided meeting requirements in this Section.
- B. Ducts shall be machine formed round duct constructed of G90 galvanized steel. Use spiral lockseam construction unless otherwise indicated. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
- C. Connection shall use slip coupling, angle ring or Van Stone Connectors in accordance with manufacturer's recommendations.
- D. Round spiral duct gauge/reinforcement shall be as follows:

<u>Duct Diameter</u> (Inches)	<u>-10 to -20" WG</u> <u>Gauge/Reinforcement</u>
3 - 7	26 ga
7-1/2 - 8	26 ga
8-1/2 - 12	24 ga
12-1/2 - 15	22 ga
16 - 18	20 ga
19 - 22	18 ga
23 - 26	18 ga
27 - 34	18 ga w/AR 12 ft c/c or 16 ga
35 - 42	18 ga w/FL + AR 6 ft c/c or 16 ga w/FL
44 - 50	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
52 - 60	18 ga w/FL + AR 4 ft c/c or 16 ga w/FL
62 - 72	16 ga w/FL + AR 6 ft c/c or 14 ga w/FL

AR = single angle ring reinforcement at maximum indicated ft on center spacing.

FL = fully welded flange angle rings as joint connections at maximum 12 ft spacing.

- E. Fitting gauge shall be one even gauge heavier than the lightest allowable gauge of connecting downstream section of duct.

2.05 MANUFACTURED SELF-SEALING ROUND DUCTWORK SYSTEM

A. Single-wall:

1. Manufacturers: Lindlab Spirosafe or Tambe Metal Products SPIRAmir.
2. Ductbank system shall consist of fittings with factory-fitted sealing gasket and spiral duct which will seal duct joints without use of duct sealer.
3. Ducts shall be machine formed round as shown on drawings, constructed of G90 galvanized steel. Use spiral lockseam construction. Use fittings as indicated on drawings, as specified, and as required in accordance with manufacturer's published data.
4. Unless otherwise noted, duct and fittings shall be constructed per SMACNA's Duct Construction Standards (+10 in WG) shown in the following table:

<u>Diameter (inches)</u>	<u>Galvanized Spiral Duct</u>	<u>Galvanized Fittings</u>
3-14	26	24
16-26	24	22
28.36	22	20
38-50	20	20

5. All fitting ends shall have factory equipped with double-lipped, U-profile or tubular EPDM rubber gasket. Gasket shall be classified by Internationally Recognized Laboratory Authority to conform to ASTM E84-91a and NFPA 90A flame spread and smoke developed ratings of 25/50.
6. Ductwork system performance shall meet SMACNA's Leakage Class 3 Requirements from -20" WG to +12" WG.

2.06 PERFORATED ROUND DUCT

- A. Manufacturer: United McGill
- B. Type DDFSP with internal orifice rings
- C. See plans for lengths and details.

2.07 DUCT SEALANT AND GASKET

A. Sealant:

1. UL Classified sealant as compounded specifically for sealing joints and seams in ductwork. Hardcast, United McGill, Ductmate, Mon-Eco Industries or H.B. Fuller/Foster. Duct tapes are not allowed.
2. Select sealants as recommended by manufacturer for specific application.
3. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, detailed installation instructions.
4. Caulk-type sealant shall be used on all exposed ductwork other than in mechanical rooms.

B. Gaskets:

1. Butyl, copolymer or neoprene based tape similar to Ductmate 440 Gasket Tape or Neoprene Gasket Tape for flanged joints.

C. Duct Sealant and Gaskets for Fume Hood Exhaust Ductwork:

1. Chemical resistant sealant similar to Hardcast.
2. Gasket material shall be Teflon based similar to Gore-Tex Series 300 or Butyl based tape similar to Ductmate 440 Gasket Tape.

3. Gasket thickness and width shall be as required for flange and surface irregularities to seal joint air tight.

2.08 ACOUSTIC ENCLOSURE

- A. Enclosure to consist of inner layer (2" thick, minimum 3 psf glass or mineral fiber similar to Type R insulation specified in Section 15250 - Mechanical Systems Insulation) and outer layer of 2 layers of 5/8" sheet rock with staggered seams, attached to sheet metal studs. Sheet rock shall be attached to structure not ductwork.

2.09 ACOUSTIC DUCT COVERING

1. Sound barrier material shall be similar to Kinetics Model KNM-100B or EAR Lag-10. Barrier material to have acoustic ratings of STC-27, 1.0 lb/ft² weight, and minimum continuous operating range from -10 to 180°F.
2. Minimum sound transmission loss at each octave band shall be as follows:

<u>Sound Transmission Loss (dB)</u>					
<u>Octave Band Center Frequency (Hz)</u>					
<u>125</u>	<u>250</u>	<u>500</u>	<u>1000</u>	<u>2000</u>	<u>4000</u>
15	18	21	27	32	37

PART 3 - EXECUTION

3.01 GENERAL

- A. Install ductwork parallel to building walls and ceilings and at such heights not to obstruct any portion of ceiling, window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical ductwork plumb. Where interferences develop in field, offset or reroute ductwork as required to clear such interferences. In all cases, consult drawings for exact location of duct spaces, ceiling heights, door and window openings or other Architectural details before installing ductwork.
- B. Make allowances for beams, pipes or other obstructions in building construction and for work of other Contractors. Check plans showing work of other trades and consult with Engineer in event of interference. Transform, divide, or offset ducts as required, in such a manner as to maintain same cross sectional area of duct as indicated on drawings. Where it is necessary to install pipes or similar obstructions through ducts, ducts need not be enlarged if decrease in area does not exceed 10%. If decrease in area would exceed 10%, enlarge duct to maintain duct area not less than 90% of that shown on drawings. In all cases, provide streamlined encasement or collar designed in accordance with SMACNA Standards and seal to prevent air leakage.
- C. Ductwork shall be free of kinks and dents.
- D. Fabricate and install duct, fittings, joints, seams, reinforcement, supports, sealing, liner, etc., in sizes indicated on drawings and in accordance with manufacturer's published data and SMACNA Standards except as modified in this Section of Specifications.
- E. Provide transitions where different size or different shape ductwork segments are connected. Use concentric transitions unless otherwise shown. Unless otherwise indicated, make diverging transitions with maximum angle of 15 degrees per side (30 degrees total diverging) and converging transitions with maximum angle of 25 degrees per side (50 degrees total converging).

- F. Provide transitions at ductwork system components and connections to equipment. Refer to Specification Section 15936, for additional information regarding diffuser/register/grille connections.
- G. Refer to ductwork symbols list on drawings for additional and dimensional requirements for fittings.
- H. Seal duct seams and joints to meet SMACNA Class A as minimum for all ductwork including low-pressure ductwork.
- I. Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to Part 1, Design Criteria for internal tie rods.
- J. Support coils, filters, air terminals, dampers or other devices installed in duct systems with angles or channels, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.
- K. Air terminal devices may be supported by strap hangers if air terminal manufacturer approves. Strap hangers are not allowed for fan powered devices, double wall type and Titus Steri-Loc type devices.
- L. Install outside air intake duct to pitch down at 1" per 20 ft toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.
- M. Blank off unused portion of outside air intake or exhaust louvers.
- N. Where 2 different metal ducts meet, install joint in such a manner that metal ducts do not contact each other by using proper gasket seal or compound.
- O. Install motor operated dampers and connect to or install equipment furnished by others. Provide necessary blank-off plates or transitions to mount control dampers as specified in Section 15950 – Temperature Control System.
- P. Do not install ductwork over electrical panelboards, switchgear, switchboards or motor control centers.
- Q. When original galvanized finish is altered or damaged, apply field galvanizing paint as follows:
 - 1. Prepare surface with use of power sanders or wire brushes to remove rust, paint, etc.
 - 2. Apply cold galvanizing material equal to ZRC Products, Inc.

3.02 ELBOWS

- A. Rectangular Duct:
 - 1. Unless specific type is indicated, use radius elbows with minimum centerline radius to width or diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use the following elbows:
 - a. Supply Air Ductwork:
 - 1). 1.0 radius elbows with splitter.
 - 2). Square elbows with single wall turning vanes where 1.0 radius elbows do not fit.
 - b. Return or Exhaust Air Ductwork:
 - 1). 1.0 radius elbows with full splitter vanes as follows:
 - a). One vane for duct width 24" to 48".
 - b). Two vanes for duct width 49" to 72".
 - c). Three vanes for duct width 73" and larger.
 - d). Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standard, pages A41 through A43.

- 2). 45 degree mitered throat with radius heel elbows with full splitter vanes as follows where 1.0 radius elbows do not fit:
 - a). One vane for duct width 12" to 24".
 - b). Two vanes for duct width 25" to 36".
 - c). Three vanes for duct width 36" and larger.
 - d). Fabricate vanes in accordance with SMACNA HVAC Duct Construction Standards, pages A41 through A43.
- 3). Square throat - radius heel elbows or square throat elbows with turning vanes are not allowed unless specifically indicated.
- 4). Provide access panels (not doors) upstream of elbows for cleaning.

B. Round and Oval Duct:

1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.

3.03 LONGITUDINAL SEAM

A. Rectangular Duct:

1. Unless otherwise indicated, use Pittsburgh Lock Seam for rectangular ductwork except button punch snap lock may be used for ductwork downstream of supply air terminal devices.
2. Button punch snap lock construction is not allowed on aluminum ductwork.

B. Round and Oval Duct:

1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards. Snaplock seams are not allowed.

3.04 TRANSVERSE JOINT

A. Rectangular Duct:

1. Transverse joints shall be in accordance with SMACNA HVAC Duct Construction Standards.
2. Ductmate 25/35 connection systems with corner clips or optional nuts and bolts may be used. Incorporate use of all Ductmate accessories to ensure integrity of transverse connection. Install joints in strict accordance with the latest edition of Ductmate 25/35 Assembly and Installation Instruction Manual and Duct Construction Standards. Nexus or WDCI will be acceptable.
3. Lockformers TDC or Engles TDF may be used in accordance with T-25 flanges of SMACNA HVAC Duct Construction Standards, Metal and Flexible, Second Edition, 1995, provided that corner pieces with bolts are used. If TDF/TDC flanges are damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2 x 1-1/2 x 1/4 angle at each side of transverse joint.

B. Round and Flat Oval Duct:

1. Unless otherwise indicated, use beaded sleeve joints (SMACNA RT-1) with minimum 2" insertion length or flange joints (SMACNA RT-2 or RT-2A).
2. Connection systems manufactured by Ductmate Industries (Spiralmate and Ovalmate) may be used for supply air ductwork.
3. AccuFlange connected systems may be used with gaskets specified in Part 2 of this Section.
4. Lindab SPIROsafe "self-sealing" duct system will be acceptable for supply and return air ductwork.

3.05 DUCT SUPPORTS

- A. Unless otherwise indicated, use trapeze hangers with rods or angles to support the following rectangular ductwork:
 - 1. Non-insulated ductwork 48" and wider.
 - 2. Externally insulated ductwork.
- B. For round ducts 24" diameter or smaller, use single hanger.
 - 1. Cable Suspension System may be used up to 16" diameter.
 - 2. Round Duct Strap Bracket by Ductmate Industries may be used up to 24" diameter.
- C. For round ducts over 24" diameter, use 2 hanger rods with half round trapeze. Trapeze shall be in accordance with the following schedule:

<u>Duct Size</u>	<u>Trapeze (Half Round)</u>
25" through 36"	2" x 10 gauge
37" through 48"	1-1/2" x 1-1/2" x 1/4"
49" through 60"	2" x 2" x 1/4"
61" through 84"	2-1/2" x 2-1/2" x 1/4"

- D. Refer to Section 15250 - Mechanical Systems Insulation, for ductwork insulation, weight bearing inserts and insulation protection shield requirements.
- E. Support ducts located on roof as detailed.
- F. Support vertical ducts at every floor, but not exceeding 12 ft.
- G. The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
 - 1. Hook or loop.
 - 2. Nailed pin fasteners.
 - 3. Expansion nails without washers.
 - 4. Powder charged or mechanically driven fasteners (forced entry anchors).
 - 5. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips for "C" clamps).
 - 6. Friction clamps for ductwork over 12".
 - 7. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 4-3 of SMACNA HVAC Duct Construction Standards 95).
 - 8. Wire hanger.
 - 9. Trapeze hangers supported by wires or straps.
 - 10. Rods, straps or welded studs directly attached to metal deck.
 - 11. Drilled hole with attachment to structural steel.
 - 12. Lag screw expansion anchor.
 - 13. Rivets.
- H. Supporting devices shall be standard products of manufacturers having published load ratings.
- I. Refer to Section 15065 - Mechanical Supporting Devices, for additional support requirements including attachments to structures.

- J. For welded ducts, soldered ducts or ducts with water tight joints, do not use supports utilizing screws or other penetrations into ductwork.
- K. Unless Architectural Documents indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with the Project Structural Engineer for location and size of opening prior to execution of Work.

3.06 PROTECTION OF DUCTWORK

- A. Protect ductwork during construction against entry of foreign matter and construction dirt.
- B. Keep ductwork capped when work is complete for the day or when duct is not being worked on or added to. Use of polyvinyl (VISQUEEN) with duct tape wrap is an adequate measure as long as it is secure with no openings or tears in product.

3.07 LEAKAGE TEST

- A. Owner and/or Owner's representative will witness leakage tests performed by Mechanical Contractor. Notify Owner and/or Owner's representative at least 3 days in advance.
- B. Test all ductwork unless otherwise indicated in this Section. Test all ductwork upstream of take-offs to boxes prior to cutting in the take-offs.
- C. Leakage test shall be in accordance with test method described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual, except as modified in this Section.
- D. Test pressure shall be equal to duct pressure class. Negative pressure ductwork shall be tested with negative test pressure.
- E. Air leakage shall not exceed limits specified. If leakage exceeds allowable limits, identify leaked areas, repair, seal and retest.
- F. Do not insulate ductwork until it has been successfully tested.
- G. Leakage rate shall not exceed more than 2% of system design air quantity for low-pressure ductwork, determined in accordance with Appendix C of SMACNA HVAC Air Duct Leakage Test Manual.
- H. Leakage rate shall not exceed more than 1% of system design air quantity for high-pressure ductwork, determined in accordance with Appendix C of SMACNA HVAC Air Duct Leakage Test Manual.
- I. Welded ductwork shall be airtight and shall have no air leakage.
- J. Leakage Test for Ductwork Downstream of Air Terminal Devices:
 - 1. Representative samples of ductwork (approximately 10% of total linear feet of ductwork) shall require leakage test.
 - 2. Engineer will decide samples of ductwork to be tested and date of leakage test to be conducted.
 - 3. If test results are acceptable to Engineer, remainder of ductwork is permitted to proceed without further testing. If ductwork fails test, repair all ductwork including ductwork not tested. Then repeat leakage tests for new samples of ductwork as described above.

3.08 LOW PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 2" AND UNDER)

- A. Use welds, rivets or nuts, and bolts for fabricating ductwork. Fully threaded sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if screw does not extend more than 1/2" into duct. Sheet metal "TEK" screws 3/4" in length may be used as fasteners in conjunction with factory made transverse joints.
- B. Unless otherwise indicated, construct branch take-off fittings as follows:
 - 1. For branch take-offs including branch ducts serving more than one diffuser or grille, use 45 degree entry fittings. For supply air ducts, expanded or conical taps may be used.
 - 2. For take-offs serving single diffuser, register or grille, use straight spin-in collars with manual balancing dampers.
- C. Do not use splitter dampers and/or extractors unless manual volume dampers alone do not accomplish the intended balancing. Obtain Engineer's written approval before installing them. Use of splitter dampers and/or extractors will not eliminate need for specified or indicated manual volume dampers.

3.09 HIGH PRESSURE DUCT CONSTRUCTION (PRESSURE CLASS 3" AND OVER)

- A. Use manufactured ductwork or Contractor fabricated ductwork meeting specified Construction Standards.
- B. Submit construction details including materials, type of service, reinforcing methods, and sealing procedures.
- C. Use elbows, tees, laterals, crosses and accessory fittings as shown on drawings and as required to fabricate duct system.
- D. Use expanded or conical tees for branch take-offs from mains.
- E. Provide manufactured bellmouth fittings at each fan supply air plenum to provide smooth entrance of air into duct system.
- F. Provide positive pressure relief doors as indicated on drawings.
- G. Provide negative pressure relief doors as indicated on drawings.
- H. Construct high pressure ductwork for 6 inch WG pressure class.
- I. Ductwork pressure class is indicated on drawings.

3.10 FLEXIBLE DUCT

- A. Install flexible duct as specified below.
- B. Install flexible ducts in accordance with manufacturer's installation instructions and SMACNA Standards, except as modified in this Section of Specifications.
- C. In supply air systems without air terminal devices, flexible ducts may be used for final connections to diffusers, grilles, and registers. Flexible ducts shall be of minimum length required to make connections, but shall not be greater than 6 ft in length, unless noted otherwise.
- D. In supply air systems with air terminal devices, flexible ducts shall be used for duct connections to diffusers, grilles, and registers for sound attenuation purposes, except above non-accessible ceilings. Flexible ducts shall be minimum 3 ft long and maximum 6 ft long.

- E. Flexible ducts may be used for final connections to return grilles and registers and general exhaust grille and registers. Flexible ducts shall be of minimum length required to make connections, but no greater than 6 ft in length, unless noted otherwise.
- F. Flexible ducts are not allowed for special exhaust systems, such as fume hood exhaust, animal room exhaust, cagewash exhaust, shower room exhaust, kitchen hood exhaust, dishwasher exhaust, etc.
- G. Centerline radius of bends shall not be less than one duct diameter.
- H. Support flexible ductwork at a maximum of 3 ft on center, with no portion lying on ceiling supporting system.
- I. Individual sections of flexible ductwork shall be of one-piece construction. Splicing of short sections is not allowed.
- J. Connect flexible duct liner to collars with metal draw bands. If collars have beads, position draw bands behind beads.
- K. Pull insulation and vapor barrier jacket over liner connection and secure with draw band. For terminations at externally insulated ductwork, fittings, grilles, diffusers, etc., secure flexible duct jacket to ductwork insulation jacket with compatible vapor barrier tape.
- L. Flexible ducts are not allowed above non-accessible ceilings.
- M. Flexible ducts are not allowed in high pressure ductwork.
- N. Flexible ducts are not allowed to pass through any partition, wall, floor or ceiling.

3.11 ACOUSTIC DUCT COVERING

- A. Wrap outside of duct with inner layer material. Apply outer layer material over inner layer material. Do not rigidly tie outer layer material to ductwork.
- B. If manufactured barrier materials are used, install in accordance with manufacturer's installation instruction.
- C. Apply covering to the following ductwork:
 - 1. Ductwork as indicated to be covered.

3.12 WELDING EXHAUST DUCT CONSTRUCTION

- A. General:
 - 1. Construct elbows with centerline radius to width or diameter ratio of at least 1.5 and 45° lateral branch take-offs from mains.
- B. Internal bracing or tie rods are not allowed.
- C. Duct pressure class shall be as follows:
 - 1. Negative 10 inches WG for all welding exhaust ductwork.

D. Galvanized Steel Ducts:

1. Use galvanized steel sheet, Class 2, spiral seam construction.
2. Refer to Manufactured Round Ductwork (Negative pressure) in Part 2 of this Section.

END OF SECTION 15900

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SECTION 15910 - DUCTWORK SPECIALTIES

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.02 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 1. Manufacturer's name and model number.
 2. Capacities.
 3. Temperature/pressure ratings.
 4. Materials of construction.
 5. Dimensions.
 6. Manufacturer's installation instructions and/or detailed drawings.
 7. All other appropriate data.

1.03 DESIGN CRITERIA

- A. Products and materials shall conform to NFPA Section 90A, possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Ductwork specialties exposed to air stream, such as dampers, turning vanes and access doors, shall be of same material as duct at where the specialties are mounted, unless otherwise noted.
- C. Unless otherwise noted, ductwork specialties shall be designed and manufactured to conform to same pressure class as ductwork in which they are installed.

PART 2 - PRODUCTS

2.01 MANUAL BALANCING DAMPERS

- A. Manufacturers: no preference, constructed in accordance with SMACNA HVAC Duct Construction Standards, except as modified below.
- B. For damper blade width up to 12", use single blade type with minimum 20 ga galvanized steel blade for blade length up to 18", and with minimum 16 ga for blade length from 19" to 48". For damper blade width more than 12", use multiple blade type with minimum 10 ga galvanized steel channel frames, opposed blade linkage operation, with blades minimum 16 ga and 8" maximum blade width and 1/2" x 1/2" x 1/8" galvanized steel blade stops. Construct dampers over 48" in width or length in multiple sections with mullions.
- C. Rectangular Dampers:
 1. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 5" WG at closed position and maximum velocity of 4000 fpm at open position. Frame and blades shall be constructed of minimum 16 ga with minimum 1/2" diameter or square rod.
- D. Single blade round damper shall have 20 ga blades up to 12" diameter with minimum 3/8" diameter continuous shaft. Single blade round dampers shall have 14 ga blades over 12" diameter with minimum 1/2" diameter continuous shaft.
 1. For high pressure ductwork, damper blade shall be minimum 16 ga. Rod shall be minimum 1/2" square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.

- E. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.
- F. Provide sealed end bearings and acorn nut type regulators for balancing dampers for high pressure ductwork. Use elevated regulators for insulated ducts to accommodate specified insulation thickness.
- G. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.
- H. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.

2.02 SLIDE GATES

- A. For slide gates required at fume hoods. See plans and details for locations.
- B. Manufacturers: Ajax, Semco, or United Sheet Metal
- C. Units shall be fabricated of 12 ga hot rolled steel, pressure rated for 25" WG, with knife type blades. Design shall be such that all edges are out of air stream when dampers are closed. Furnish with position locking devices.
- D. Units shall be designed with positive seal. Knife blades shall be totally enclosed with sealing nut and gasket for positioning arm. Units shall be equal to United McGill Model SRFIBGP.

2.03 TURNING VANES

- A. Square Throat Elbow Turning Vanes (Vane Runner Length up to 18" and Vane Length up to 36"):
 - 1. Use single blade type vanes having 2" radius and 1-1/2" spacing, 24 gauge minimum. Construct vanes in accordance with SMACNA HVAC Duct Construction Standards.
 - 2. If duct size changes in mitered elbow, use single blade type vanes with trailing edge extension.
- B. Radius Elbow Splitter Vanes:
 - 1. Splitter vanes for radius elbows shall be extended entire length of fitting and constructed in accordance with SMACNA HVAC Duct Construction Standards. Install only where indicated on drawings.

2.04 RADIUS ELBOWS

- A. Radius elbows shall have inner radius not less than the depth of the duct extending beyond the radius.

2.05 ACCESS DOORS

- A. Access doors shall be rectangular, sturdy, fit air tight with gasket and shall be suitable for duct pressure class. Doors shall be double-wall, insulated when installed in insulated ductwork or unit casing and located for greatest ease of access. Round access doors are not acceptable. Access doors constructed with sheet metal screw fasteners are not acceptable.
- B. Low Pressure Ducts (Pressure Class 2" and Under):
 - 1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
 - 2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 2-12) or similar to Ruskin Model ADC or ADH will be acceptable.
 - 3. Access doors made by Ductmate or Ward Industries are acceptable, provided that they meet insulation requirements and include edge protection.
- C. High Pressure Ducts (Pressure Class 3" and Over):
 - 1. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10" WG.

- 2. Access doors made by Ductmate or Ward Industries are acceptable, provided that they meet insulation requirements and include edge protection.

2.06 FLASHINGS

- A. Construct counterflashings of 16 ga galvanized Armco Zinc-Grip. Flashings are by General Contractor unless otherwise indicated.

2.07 DUCT FLEXIBLE CONNECTIONS

- A. Manufacturers: Ventfabrics, Inc. or Duro Dyne, equal to Ventfabrics model indicated. Material shall be glass fabric, fire retardant, waterproof, air tight and comply with UL Standard 214 and NFPA 90A.
- B. Special Exhaust Ductwork (Welding):
 - 1. Material for indoor use shall be combination of inner layer of 14 ounce per yard, teflon coated, suitable for -20 to 500°F, equal to Ventel and outer layer of Ventglas. Apply Teflon coated side for inside where exposed to contaminated exhaust air.
 - 2. Material for outdoor use shall be combination of inner layer of Ventel and outer layer of Ventlon.

2.08 INSTRUMENT TEST HOLES

- A. Manufacturers: Ventlok 699 (up to 1" insulation thickness) or Ventlok 699-2 (over 1" insulation thickness).
- B. Use concave gaskets for round ductwork.

2.09 CONTROL DAMPERS

- A. Furnished by Control Contractor.

PART 3 - EXECUTION

3.01 MANUAL BALANCING DAMPERS

- A. Install manual balancing dampers in all branch ducts of supply, return and exhaust ductwork, as indicated on drawings and as required to regulate airflow to meet air balance requirements.
- B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.
- C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.
- D. Balancing damper is not required where terminal air device serves a single diffuser or grille.

3.02 ACCESS DOORS

- A. Install access doors as specified, as indicated on drawings, and anywhere that provision for maintenance, service, cleaning or examination is required, including each automatic damper, damper, fan bearing, reheat coils, upstream of exhaust air ductwork elbows, and valve and control device within duct or casing.
- B. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

<u>Rectangular Duct Size</u>	<u>Minimum Access Door Quantity and Size</u>
15" and smaller	(1) 16" x 12"
22" - 47"	(1) 18" x 18"
48" - 96"	(2) 24" x 24"

<u>Round Duct Size</u>	<u>Minimum Access Door Size</u>
10" and smaller	8" x 4"
15" and smaller	12" x 8"
29" and smaller	16" x 12"
30" and over	24" x 18"

C. Increase duct size to accommodate access door size indicated above where required.

3.03 FLASHINGS

A. Install counterflashings where shown on drawings. Install in accordance with SMACNA recommendations.

3.04 DUCT FLEXIBLE CONNECTIONS

A. Install duct flexible connections for connections to ductwork or equipment casing containing rotating devices including air handling units and fans. Installed width shall be suitable for specific application but shall not be less than 4". Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.

3.05 CONTROL DAMPERS

A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.

B. Install blank-off plates or transitions as specified in Control Sections.

C. Provide adequate operating clearance and access to operators.

3.06 INSTRUMENT TEST HOLES

A. Provide instrument test holes at air entering and air leaving side of all internal air handling system components for static pressure differential (Delta P) or temperature differential (Delta T) measurements.

B. Provide instrument test holes at all ducts insulated with Type R insulation, as directed by TAB personnel, Engineer or as shown on drawings.

END OF SECTION 15910

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SECTION 15930 - AIR TERMINAL DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15830 - Heating and Cooling Terminal Devices
- B. Section 15900 - Ductwork (Support)
- C. Section 15910 - Ductwork Specialties (Access Doors)
- D. Section 15950 – Temperature Control System

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number.
 - 2. Identification as referenced in the Documents.
 - 3. Capacities/ratings.
 - 4. Materials of construction.
 - 5. Sound rating data.
 - 6. Dimensions.
 - 7. All other appropriate data.

1.04 DESIGN CRITERIA

- A. Where any of air terminal devices are indicated on drawings to control space conditions in conjunction with reheat coil, that reheat coil may be furnished as integral part of or standard accessory to devices specified below. See related work above.
- B. When air terminal devices are furnished with reheat coils, either integrally or remotely mounted, control panels of terminal devices shall be mounted on the same side of air terminal device as reheat coil piping connection.
- C. Unless otherwise stated, units shall be system pressure independent and maintain air volume within $\pm 5\%$ of required airflow regardless of system air pressure. Inlet velocity pressure sensor shall be multi-point center averaging type and be capable of amplifying pressure signals.
- D. Unless otherwise stated, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 22 gauge.
- E. Joints and seams of air terminal devices shall be sealed with appropriate sealant to minimize casing air leakage. Seal joints and seams not factory sealed in field as specified in Part 3.
- F. Unit performance shall be certified in accordance with ARI Standard 880 including sound rating data certified for both casing discharge and radiated sound levels from 125 through 4000 Hz.

- G. Supply air units shall be capable of operating from minimum inlet static pressure scheduled to 3" WG.
- H. Provide supply air units with internal thermal insulation faced with minimum 0.001" thick aluminum foil. Insulation shall be compressed glass fiber with minimum 3/4" thick, 4 lb/ft³ density with R-value of 3.5. Insulation and facing shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), and NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance). Secure liner with full-seam-length, galvanized steel angles or Z-strips, which enclose and seal all edges. Tape or adhesive will not be acceptable. Liner assembly shall be similar to Titus Steri-Loc.
- I. Supply air units shall be lined with engineered polymer foam insulation, minimum 3/8" thick, 1.5 lb/ft³ density and thermal conductivity not more than 0.25 at 75°F. Insulation shall meet requirements of UL 181 (Air Erosion, Mold growth and Humidity), NFPA 90A (Flame 25/Smoke 50) and ASTM C665 (Fungi Resistance).
- J. Sound attenuators, where specified or required to meet sound performance specified for air terminal devices, shall be constructed of all metal or sound attenuating fiber material with erosion protection liner as required to meet sound requirement specified.
- K. Unit manufacturer or manufacturer's designated representative will be required to verify air terminal device performance and adjust or replace device within warranty period when it is determined that problem exists in area served by device.

1.05 CONTROLS COORDINATION

- A. Unit manufacturer shall provide unit inlet flow sensor, pneumatic tubing and control enclosure for Control Contractor's use.
- B. Control Contractor shall furnish all actuators, linkages if required, differential pressure transmitters, controllers and any other devices required for unit control that are not provided by unit manufacturer and shall field install.
- C. Control Contractor's field mounting will be acceptable, provided Control Contractor coordinates proper installation with unit manufacturer. Control Contractor shall be responsible for complete functioning unit.

PART 2 - PRODUCTS

2.01 VARIABLE VOLUME AIR TERMINAL DEVICES

- A. Manufacturers: Carnes, Titus, E. H. Price, Krueger, Metal-Aire, Enviro-Tec, Nailer, Tuttle and Bailey, Trane or Carrier.
- B. Units shall be suitable for 24 volt electric control system. Control Contractor shall be responsible for wiring from control panels to each terminal unit.
- C. Units shall be capable of modulating to full closed position with maximum leakage of 1%.
- D. Furnish units with reheat coils having capacities as indicated in schedules.
- E. Provide access doors for all air terminal devices with reheat coils at inlet side of coils. Refer to Section 15910 - Ductwork Specialties, for access doors. Unit manufacturer's standard access doors are acceptable, provided that access doors are appropriately sized and internally lined with same materials as unit casing. If access doors are provided in separate sections as extension of units, these sections shall be internally lined in same manner as units.

- F. Units to include damper control section and sound attenuation section as complete factory assembled unit. Damper control outside of unit.
- G. Unit shall be capable of handling minimum of 5-inches of static pressure.
- H. Units shall be independent of pressure variations and capable of operating satisfactorily throughout the control range, from minimum to maximum air flow.
- I. Calibrate volume control to identify air volume in increments of percent of maximum air flow.
- J. Sound attenuating device: Manufacturer provided sound attenuating device provided to meet noise requirements of space.

2.02 VENTURI TYPE AIR TERMINAL DEVICES

- A. Manufacturers: Phoenix Controls.
- B. Units shall be linearized Venturi type pressure independent and capable of modulating to fully closed position.
- C. Units shall be suitable for electric/electronic actuators.
- D. Units shall be provided with controller which will accept hardwired analog flow control signal from BAS.
- E. General Exhaust Air Valves:
 - 1. Unit housings and cones shall be uncoated aluminum construction. Shaft and all hardware exposed to airstream to be 316L stainless steel.
- F. Sound attenuating device: Manufacturer provided sound attenuating device provided to meet noise requirements of space.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units as shown on drawings and according to manufacturer's instructions.
- B. Install units with sufficient service space to unit control, actuators and access panels.
- C. Seal joints and seams of units not factory sealed to meet allowable leakage rate specified for low pressure ductwork.
- D. Connect terminal devices to ductwork with removable type joints.
- E. Provide minimum length of 3 times box inlet diameter of straight rigid duct at box inlet.
- F. Provide access doors for terminal devices with reheat coils at inlet side of coils.

END OF SECTION 15930

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SECTION 15936 - DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.02 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 1. Manufacturer's name and model number.
 2. Identification as referenced in the Documents.
 3. Capacities/ratings.
 4. Materials of construction.
 5. Sound ratings.
 6. Dimensions.
 7. Finish.
 8. Color selection charts where applicable.
 9. Manufacturer's installation instructions.
 10. All other appropriate data.

1.03 DESIGN CRITERIA

- A. Performance data shall be based on tests conducted in accordance with ASHRAE Standard 70.
- B. Screw holes on surface shall be counter sunk to accept recessed type screws.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Anemostat, Titus, E. H. Price, Carnes, Metal-Aire, Nailor, Tuttle-Bailey or Krueger.
- B. Acceptable manufacturers for specialty products are listed under each item.

2.02 CEILING DIFFUSERS

- A. Diffusers shall be aluminum or steel as scheduled, unless otherwise indicated, and furnished with frame type appropriate to installation. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 times duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.
- B. Diffuser models, sizes and finishes shall be as shown on drawings and/or as scheduled. Unless noted otherwise, diffusers shall have baked enamel finish with color selected by Architect.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.
- B. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar sizes. Where diffuser or grille has square neck, provide round-to-square duct transition to allow connection of flexible duct.
- C. Seal connections between ductwork drops and diffusers/registers/grilles air tight.
- D. Blank off unused portion of linear diffusers and grilles.
- E. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

END OF SECTION 15936

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SECTION 15950 – TEMPERATURE CONTROL SYSTEM

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15055 - Motors
- B. Section 15240 – Mechanical Noise and Vibration Control
- C. Section 15930 - Air Terminal Devices
- D. Section 16110 - Raceways
- E. Section 16120 - Wire and Cable

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DEFINITIONS

- A. These specifications and drawings require finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready for use."
- B. "Contractor" shall mean the Controls Contractor performing work under this Division of the Specifications.
- C. Where this specification states work to be performed by the words "shall" or "secure" or other performance functions, it shall be assumed that such work shall be performed by this Contractor unless stated otherwise.
- D. The word "Mechanical" applies to all work specified herein wherever applicable.
- E. The phrase "Architect/Engineer" implies that either may perform the task at hand.
- F. The phrases "University Engineer" or "Owner's Representative" implies an assigned representative from the UCB Facilities Management Department.
- G. The term "UCB HVAC Shop" or "CU HVAC Shop" implies a representative of the HVAC shop of the University of Colorado Boulder.
- H. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.
 - 1. Actuator: Control device to provide motion of valve or damper in response to control signal.
 - 2. AI: Analog Input
 - 3. AO: Analog Output
 - 4. Analog: Continuously variable state over stated range of values
 - 5. Auto-Tune: Software routine used to adjust tuning parameters based on historical data.
 - 6. BAS: Building Automation System

7. BMS Building Management System
8. DDC: Direct Digital Control
9. DDCP: Direct Digital Control Panel
10. Discrete: Binary or digital state
11. DI: Discrete Input (Sometimes referred to as Binary Input BI)
12. DO: Discrete Output (Sometimes referred to as Binary Output BO)
13. EMCS: Energy Management and Control System (Typically interchangeable with BAS or BMS)
14. E/P: Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
15. FA Field Adjustable
16. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
17. FMS: Facility Management System linking two or more BAS
18. FO: Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
19. I/P: Current to pneumatic transducer
20. Instrument: Device used for sensing input parameters or used for actuation.
21. Modulating: Movement of control device through an entire range of values proportional to an infinitely variable input value.
22. Motorized: Control device with actuator
23. NC: Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
24. NO: Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
25. Node: DDCP, operator workstation, or other control device connected to communications network.
26. Operator: Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
27. PC: Personal Computer
28. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
29. P: Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
30. PI: Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
31. PID: Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
32. Point: Analog or discrete instrument with addressable database value.
33. Self-Tune: Same as Auto-Tune
34. Solenoid: Electric two-position actuator. (See E/P.)
35. TCC: Temperature Control Contractor (Same as Control Contractor)
36. TCP: Temperature Control Panel

1.04 ACCEPTABLE CONTROL CONTRACTORS

- A. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:
 - 1. Andover Controls.
- B. Currently, there are three approved Controls Contractors allowed to bid on projects utilizing Andover Controls products on the campus:
 - 1. Arkay Services
 - 2. Rocky Mountain Power and Controls with UCB pre-approval
 - 3. Westover Controls

1.05 SYSTEMS DESCRIPTION

- A. Existing building control system shall be 100% DDC. All work performed as part of this project shall seamlessly integrate into the existing Andover building control system.
- B. All damper and valve actuators shall be electric. If field conditions appear to require another type of actuator, the University HVAC Shop shall be consulted, through the Engineer, for review and approval.
- C. Provide updated BAS architecture consisting of communication network, operator workstations, modular designed DDCPs with points addressable and modifiable from operator workstations or from master DDCP using laptop computer.
- D. All digital and analog control loops shall be microprocessor (DDC) controlled with electronic final control elements, unless otherwise shown on the Drawings.
- E. System shall support operator workstations as specified and shall be capable of supporting additional workstations, limited only by systems maximum node capacity.
- F. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.
- G. Safety devices shall function in both auto and hand modes on starter.

1.06 SCOPE OF WORK

- A. Provide labor and materials for complete fully functioning control systems in accordance with Contract Documents including this Section.
- B. Provide labor and materials for all controls work related to exhaust fan, EF-1, VFD replacement/upgrade in accordance with Contract Documents including this Section. Controls work shall include, but is not limited to disconnecting all control wiring and control conduit from existing VFD, reconnecting control wiring and control conduit to new VFD, pulling new control wiring and running new control conduit if required due to VFD configuration.
- C. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative.
- D. Control Contractor's Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.

- E. Labor shall include, but not be limited to:
1. Engineering services to size unscheduled valves and dampers and confirm sizing of scheduled valves and dampers.
 2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
 3. Engineering services for required software programming.
 4. Engineering services for graphics programming specified.
 5. Project management services as single point contact to coordinate construction related activities.
 6. Field mechanics for installation of pneumatic tubing and related control devices.
 7. Field mechanics for installation of control wiring and related control devices.
 8. Field technicians to startup, calibrate, adjust, and tune control loops.
 9. Field technicians to perform system checkout and testing, and to complete required reports.
 10. Field supervisor during controls installation and startup.
 11. Field technicians to assist Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
 12. Field representatives and/or classroom instructors to provide Owner training as specified.
- F. The system shall include all interlocks, field devices, wiring, piping, hardware, and software required to provide a complete, functional system in accordance with these specifications and drawings.
- G. The distribution of points and the type of controllers shown on the control panels depicted on the Contract Documents show the actual layout to be used by the Contractor when bidding and installing the controls. It is the Contractor's responsibility to include in his bid the cost of any additional controllers necessary for a complete job, conforming to specifications.
- H. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring and pneumatic terminations at DDCP locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.
- I. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., along with separable wells for immersion sensors and taps for flow and pressure instruments furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.
- J. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor is responsible to provide final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.
1. Electrical Contractor shall provide wiring associated with BAS as indicated on electrical plans. If final connection points for BAS power are not indicated on electrical plans, Electrical Contractor shall provide circuit breakers required to provide electrical power to DDCPs.

2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to DDCP panels or in electrical rooms and powered from dedicated electrical circuit.
 3. Should any change in number of DDCPs or addition of other electrical equipment after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of this Contractor.
 4. Coordinate with Electrical Contractor for additional power requirements.
- K. Materials shall be as specified unless approved through procedures for product substitution specified in Division 1. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within intent of specification.
- L. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.
- M. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

1.07 DRAWINGS AND SPECIFICATIONS

- A. The mechanical drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
- B. All drawings relating to this structure, together with these specifications, shall be considered in bidding. The drawings and specifications are complementary, and what is called for in either of these shall be as binding as though called for by both. Should any conflict arise between drawings and specifications, such conflict shall be brought to the attention of the Architect/Engineer for resolution.
- C. Unless otherwise indicated, all equipment and performance data listed is for job site conditions (elevation 5,400 ft.).
- D. Drawings are not to be scaled.

1.08 SUBMITTALS

- A. All shop drawings, I/O schedules, point lists, system schematics, sequences of operation, and product data shall be submitted for approval per Division 1, Section 01300.
- B. Shop drawings and/or submittals processed by the Engineer are not change orders. The purpose of shop drawings and/or submittals by the Contractor is to inform the Engineer which equipment and material he intends to furnish and install.
- C. Submittal data and shop drawings shall conform to the following requirements:
1. All shop drawings shall be prepared according to the requirements in the most current version of Division 00050 of the University of Colorado at Boulder Construction Standards (Computer - Aided Drafting and Facilities Management Standards). A copy is available upon request. Some of the requirements in this document are listed below.
 - a. Shop drawings shall be developed using the most current version of AutoCAD (Autodesk, Inc.) or a version that is 100% compatible with the current version.
 - b. Specific information shall be added to the title block of each sheet to aid in the UCB archiving/retrieval process for construction documentation. A copy of the specific requirements is available from the Facilities Management CAD Office.

2. All final or as-built shop drawings for temperature control will become permanent record documents and shall be prepared on size (36" x 24"). Plain paper and CAD files on a standard digital media (i.e., CD, Disk, Thumbdrive).
 3. All submittal data shall be bound or in a three-ring hard cover binder as appropriate. All the information shall be indexed and tabbed with reference to the specific section of these specifications. Product data sheets shall be marked with the tag number as indicated on the drawings. All options, ranges, and voltages (which will be provided) shall be clearly indicated on each product data sheet.
 4. The format for submittal information shall be as follows:
 - a. Control drawings and building plans shall be CAD-prepared drawings. Drawings that cannot represent the total information on one drawing (i.e., a building plan) shall be noted with appropriate match lines, cross references, and key plans.
 - b. The control drawing package shall consist of:
 - 1). A title sheet listing the project title, and index of all the control drawings, and a network schematic showing all DDC Panels and network connections on the project. The network diagram shall indicate all communication devices. The following information shall be provided for each network device:
 - a). Location (room number)
 - b). Power source (breaker panel I.D. and breaker number)
 - c). Panel software name and serial number
 - d). Type of controller: The network diagram shall depict the actual connection sequence of the devices, including distances between devices, type of wire used and serial number of controller.
 - 2). The second drawing in the control package shall consist of actual installation details, a valve schedule, and a damper schedule. The valve schedule shall have entries for: Valve tag, system served, quantity type (3w, 2w), GPM, actual CV, actual pressure drop, size, close off rating, spring range, part number, and manufacturer. The damper schedule shall have entries for: Damper tag, system served, quantity, type (PB, OB), CFM, size, actual pressure drop, quantity of actuators, spring range, damper model number, and, and actuator model number.
 - 3). Subsequent drawings shall depict complete systems (air handler, chiller, boiler, etc.). The drawing shall show the system schematic, all wiring of the DDC controller, all wiring of field devices, starters, and connections to equipment. Each drawing shall have a bill of materials and a sequence of operation.
 - 4). Floor plans shall depict equipment location, sensor, and panel locations. The duct and space static pressure monitor points shall be shown.
- D. Submittal data and control drawings for all equipment and systems shall be submitted (per Section 01300) to the Architect/Engineer for review prior to ordering or fabrication of the equipment. The following information shall be included in these submittals:
1. 30 Days or Less After Notice to Proceed:
 - a. Control valve and damper schedules which include size, Cv (valves), close off pressure rating (valves), [at 0 psi for N.C., two-way valves; at 20 psi for N.O., two-way valves; and at 0 psi between ports A and B for three-way valves], gpm or cfm, spring range of the actuator, quantity of actuators (dampers), and actual pressure drop for each item.
 - b. Technical specification data sheets of each system component and device which includes all data needed to show compliance with this specification.

2. 60 Days or Less After Notice to Proceed:
 - a. Control drawings with detailed piping and wiring diagrams; system schematics with controlled/monitored device locations; and connections to all enclosures, panels, and controllers, including a bill of material for all systems. Ladder-type electrical schematic diagrams shall be provided for all interlock wiring with magnetic starters, control relays, safety devices, etc.
 - b. Sequence of operation for all controlled and monitored points for each system. Sequence shall be on same drawing as corresponding system schematic.
 - c. A complete input/output schedule for each DDC panel and dedicated controller including point name (the same name to be used in software), functional description of each point, point type, complete wiring diagram for each point from controller to input or output device, field device type, and location, etc.
 - d. Communications cable schematic showing panel and controller locations, controller power source, and all interconnecting data and communication conductors. Arrange the panels in the order in which they will actually be interconnected in the field.
 - e. On control drawings show sensor, panel, and equipment locations by referring to room number. VAV boxes shall be shown indicating room number that has sensor or Smart Stat connected to controller. Also indicate, in a matrix-diagram, each room served by that zone.
 - f. DDC network configuration complete with interconnection diagrams for all peripheral devices, batteries, power supplies, etc.
 - g. A bill of material shall be shown on each drawing. The bill of material shall include the device code used on the controls drawings, description of the product, name of the manufacturer, complete model number, measurement range (if applicable), and quantity.
 - h. Identify the electrical power source for each DDC panel by location (room number), panel designation, and breaker number. Include the identification on the drawing and at the DDC panel itself. (Dedicated Powersource)
 - i. Submittals shall also include a complete test plan and procedures. Test plan shall be coordinated with the (Section 15990) Testing, Adjusting, and Balancing Contractor. The test plan shall delineate the methods of testing and recording the results of the point by point verification and calibration of the hardware and the testing and tuning of the software. The test plan shall include a listing of all hardware points with columns for calibration, test and certification. There shall be a similar record for software.
3. 14- Days Prior to System Demonstration and Acceptance Testing:
 - a. Provide software programs and sequences written in the program language and in English.

E. Completion Checklist:

1. Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
2. Checklist shall include references to the following additional requirements:
 - a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.
 - b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.
 - c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe

operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).

- d. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.
- e. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.
- f. Performance tests of discrete control loops shall be performed by, adjusting set point and verifying sequence action.
- g. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.

1.09 PROJECT RECORD DOCUMENTS

- A. Upon completion of the installation, provide a complete set of record (as-built) drawings on digital media. The content and format of the drawings shall be as described previously.
- B. Prior to Final Completion of the installation, prepare complete Operation and Maintenance manuals. Refer to Division 1, Section 01300, and Division 15, Section 15050, for requirements. Also provide one set of digital media containing all CAD-prepared drawings. The file format shall conform to the requirements in the most current version of Division 00050 of the University of Colorado at Boulder Construction Standards (Computer - Aided Drafting and Facilities Management Standards). A copy is available upon request.
 - 1. Temperature control diagrams including an explanation of the control sequence of each system along with the following instruction wherever applicable.
 - 2. Emergency procedures for fire or failure of major equipment.
 - 3. Normal starting, operating and shutdown.
 - 4. Summer or winter shutdown.
 - 5. A reduced copy of the controller drawing, listing all input and output points with functional descriptions, shall be placed inside the door to each controller enclosure in a plastic pocket attached to the door. The sheet shall be laminated. One sheet is required for each controller housed in the enclosure.

1.10 COORDINATION WITH TAB CONTRACTOR:

- A. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, Operator Workstation computers, static pressure controllers, "K" Factors for VAV boxes, or any other devices that may need set point changes so that TAB work can be performed.
- B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.11 DEMONSTRATION AND TRAINING

- A. This Contractor shall provide a minimum of 8 hours of system and control demonstration time at the job site for the Owner's personnel.
- B. A minimum of two copies of the most current control drawings shall be provided to the UCB HVAC Shop before the training begins. These shall be in addition to the drawings to be provided under Paragraph 1.08, if the O&M Manuals have not been turned in to the Architect before the time of the training.
- C. The training may be phased. The Owner may elect to conduct training and demonstration in two- to four-hour sessions over the life of the warranty period. All instructional material shall be available to each employee at each training session up to a maximum of ten (10) individuals.
- D. All demonstration and training sessions shall be coordinated with the University HVAC supervisor.

1.12 WARRANTY

- A. The warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met. Under no conditions will the Controls Warranty begin before the starting date of the General Warranty for the overall project.
 - 1. Completion of the tests required in Paragraph 1.09 and correction of all problems discovered during the testing process.
 - 2. Completion of all punch list items that are the direct responsibility of the Controls Contractor.
 - 3. Conduction of a preliminary training session for personnel of the HVAC Shop of the Department of Facilities Management. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings. A copy of the as-built control drawings shall be provided to the HVAC Shop at this time as well. Other, more detailed, training sessions (such as for review of the control programs) may be held at a later date during the warranty period
 - 4. Completion and distribution of the as-built control drawings, including correction of all items noted by the Owner and Engineer after review of the documents.
- B. The control system shall be guaranteed to be free from original defects in material and workmanship and in software design and operation for a period of one year after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure that all system and component failures are promptly repaired.
- C. The Contractor shall receive calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist. The response time to critical problems shall be four (4) hours maximum.
- D. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.
- E. The Contractor shall optimize all control software and tune all PID loops to assure acceptable operating and space conditions and peak energy efficiency. This shall include changes

needed to optimize operation of the systems even if not explicitly described in Control Strategies.

- F. The Contractor shall include the extended warranty for upgrades of Ethernet controllers installed in the building for the warranty year.
- G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all project record documentation as described in Paragraph 1.10, Project Record Documents. This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.
- H. Contractor shall notify a representative of the UCB HVAC Shop before and after performing any work on the DDC components, and report any changes made.
- I. During the warranty period, University personnel shall make a reasonable effort to determine if a problem is due to the control system or some other source not the responsibility of the Controls Contractor, before requesting warranty service. However, if the Controls Contractor is called out and determines that the problem is not due to the controls system or other building components, the Contractor shall not charge the University for a service call if it is determined that the source of the problem is not his responsibility.

1.13 QUALITY ASSURANCE

- A. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing. This requirement is not intended to restrict the Contractor to the use of outdated equipment.
- B. All products used in this installation shall be new and currently under manufacture. Spare parts shall be available for at least ten (10) years after completion of this contract.
- C. All DDC components shall be compatible with the rest of the DDC network at the beginning of the warranty period.

1.14 OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:
 - 1. Project graphic images.
 - 2. Record drawings.
 - 3. Project database.
 - 4. Job-specific application programming code.
 - 5. All other documentation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Regardless of the manufacturer, the specific products and design chosen shall meet the requirements of this specification.

- B. Control Wiring
 - 1. Inifnet Communication Wiring:
 - a. Windy City, Belden or equal: 24 gauge stranded, single twisted pair, shielded, low capacitance (less than 12.5 pico-farads/ft), 78% velocity of propagation.
- C. Local Control Panels
 - 1. Kele RET Series (color: orange)
 - 2. Panel locks utilize standard 2050 keyed locks
- D. Identification
 - 1. Wire labels
 - a. BRADY or pre-approved equal.

2.02 DISCRETE ELECTRIC INSTRUMENTATION

- A. General:
 - 1. Electrical devices, switches, and relays shall be UL Listed and of type meeting current and voltage characteristics of Project. Terminal connections shall be made at terminal blocks inside of NEMA 1 Enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
 - 2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
- B. Relays:
 - 1. Manufacturers: IDEC or approved equal.
 - 2. Equal to IDEC type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
 - 3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.
 - 4. Provide diodes to limit back EMF on all DC relays and MOVs on AC
- C. Manual Selector Station – Snorkel Exhaust System Mode Control
 - 1. Manufacturers: Allen Bradley Bulletin 800T, IDEC, Square D, or approved alternate.
 - 2. Heavy-duty nonilluminated 2-position selector switch, 24 VAC/60 Hz, 10A rated continuous selector switches with same NEMA Rating as enclosure shall be used for local interface switching. Provide 2 N.O. and 2 N.C. contacts.
 - 3. Heavy-duty illuminating Red LED pilot lights with same NEMA rating as enclosure shall be used for local interface indication. Include power module to match control system voltage to lamp.
 - 4. Switch and pilot light shall be provided in metal, surface mount NEMA 4 enclosure.
 - 5. Provide legend plate for selector switch indicating “WELD” & “OFF” switch positions.

2.03 ANALOG ELECTRONIC INSTRUMENTATION

- A. Ducted Air System Static Pressure Transmitters:
 - 1. Manufacturers: Dwyer Magnehelic Series 605 or pre-approved equal.
 - 2. Provide transducers/transmitters to convert static duct pressure relative to sensor location into electronic signal.

3. Unit shall be capable of transmitting linear 4 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
 - a. Span: Not greater than twice duct static pressure at maximum flow rate.
 - b. Accuracy: $\pm 1.0\%$ of span or $\pm 1.0\%$ of full scale
 - c. Dead Band: Less than 0.5% of output
 - d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
 - e. Linearity: Within 1.0% of span or within 0.5% of full scale
 - f. Repeatability: Within 0.5% of output
 - g. Response: Less than 1 second for full span input
4. Static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines.

B. Airflow Differential Pressure Transmitter:

1. Manufacturers: Air Monitor Corporation Veltron DPT 2500-Plus
2. Provide transmitter to convert velocity pressure differential into electronic signal.
3. Coordinate transmitter range requirement with exhaust fan supplier.

C. Duct Mounted Temperature Sensors:

1. Platinum RTD type, with the following minimum performance:
 - a. Temperature Coefficient: 0.00385 ohm/ohm/ $^{\circ}$ C
 - b. Accuracy: $\pm 0.12\%$ at 32 $^{\circ}$ F (Class B)
 - c. Conformance: DIN-IEC 751
 - d. Operating Range: -50 to 170 $^{\circ}$ F, 0 to 99% RH
2. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of $\pm 0.36^{\circ}$ F between 32 $^{\circ}$ F and 150 $^{\circ}$ F, and 0.5 $^{\circ}$ F between -20 $^{\circ}$ F and 212 $^{\circ}$ F.

2.04 TWO POSITION EXHAUST FAN ISOLATION DAMPERS:

- A. Manufacturers: Ruskin CDR25 or pre-approved equal.
- B. Galvanized steel construction, Self-lubricating stainless steel sleeve, continuous shaft with seal, suitable for maximum temperature 250 $^{\circ}$ F, approach velocity 4000 fpm, and differential pressure of 10" WC.
- C. Furnish dampers with neoprene blade seals.
- D. Damper actuators shall be fail-last-position, electric 24 VAC, as manufactured by Siemens Building Technologies. Actuator 90 $^{\circ}$ stroke time shall be 60 seconds or less. Provide dual auxiliary switches for indication of damper Open/Closed position.

2.05 GLOBE VALVES (COMMERCIAL GRADE) - TERMINAL UNITS

- A. Manufacturers ($\frac{1}{2}$ " - $\frac{3}{4}$ " size):
 1. Siemens Powermite 599 Series (electric).
- B. Manufacturers (1" and 1 $\frac{1}{4}$ " sizes only):
 1. Powers VP-658 (2-way, NO or NC), VP-658WM (3-way) and VP-591 are also acceptable.

- C. Valves shall be bronze or brass body, threaded ends for steel piping, solder ends for copper piping, ANSI Class 250 psi rating for 2" and smaller; iron body, bronze mounted, flanged, ANSI Class 125 psi rating for 2-1/2" and larger.
- D. Valves shall have stainless steel stems, spring-loaded Teflon packing, with replaceable stem/plug and packing kits.
- E. Actuators shall be electric motor/gear drives that respond proportionally to analog voltage or current input.

2.06 CONTROL WIRING

- A. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.
- B. Refer to Division 16 for specification requirements for conduits and conductors, except as noted.
- C. Cables shall be shielded when so recommended by manufacturer. Conductor size shall be in accordance with manufacturer's recommendations subject to specified minimum size. See Part 3 for allowable types.
- D. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.
- E. Raceway for wiring shall be per Division 16.
- F. The Contractor shall provide and install:
 - 1. TVSS surge protectors for incoming 120 VAC power to all controllers. Surge protectors furnished shall be UL 1449 listed.
 - 2. Transient voltage protection for all twisted pair and coaxial data communication lines between controllers. Provide all required repeaters to assure signal integrity.

2.07 LOCAL CONTROL PANELS

- A. All indoor control cabinets shall be fully-enclosed, NEMA-1 construction, with hinged door, key-lock latch, baked-enamel finish, removable sub-panels, UL-listed, wall-mounted or free-standing as indicated on plans.
- B. Panels shall house the microprocessor, communication interface, all controllers (except those required at VAV boxes), relays, indicators, clocks, switches, pilot lights, override timers, etc., to allow quick access for adjustment and troubleshooting.
- C. Internal components shall be securely mounted on removable sub-panels. Each component shall be individually labeled with function and device identification, as shown on control/interlock shop drawings.
- D. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL-listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

- E. Provide on/off power switch with over-current protection. Where multiple controllers reside in a single control panel, provide a separate disconnect (or fuse) for each controller.
- F. All control panel locks shall conform to the University standard lock for control cabinets. Contractor shall give the keys to the HVAC Shop at completion of training.

2.08 AUXILIARY DEVICES - ELECTRIC

- A. Control transformers shall be UL-listed, Class 2 current-limiting type, or shall be furnished with overcurrent protection in both primary and secondary circuits for Class 2 service.
- B. Manual control switches shall be UL-listed for use in NEMA 1 enclosures with contact arrangement and rating suitable for application. Bat handle or knob actuator with nameplate clearly identifying function of each switch position.

PART 3 - EXECUTION

3.01 GENERAL

- A. Install control equipment, wiring and air piping in neat and workmanlike manner.
- B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tapplings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.
- C. Install control devices in accessible location.
- D. No devices containing mercury shall be allowed under this Specification.
- E. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

3.02 CONTROL VALVES

- A. Furnish control valves as shown on drawings and/or as required to perform control sequences specified.
- B. Control valves furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.
- C. Increaser and decreaser fittings required to facilitate valve installations shall be provided by Mechanical Contractor.

3.03 CONTROL DAMPERS

- A. Furnish control dampers as shown on drawings and/or as required to perform control sequences specified, except those furnished with other equipment.
- B. Control dampers furnished by Control Contractor shall be installed by Mechanical Contractor under coordinating control and supervision of Control Contractor.

3.04 CONTROL WIRING

- A. All control and interlock wiring shall comply with the national and local electrical codes and Division 16 of these specifications. .

- B. All Class 1 (line voltage) wiring shall be UL-listed in approved raceway per NEC and Division 16 requirements.
- C. All low-voltage wiring shall also be in conduit. Conduit type, sizing, and installation requirements shall conform to NEC and Division 16.
- D. All cable conductors shall be minimum 18 AWG TFFN stranded. Cables shall be shielded when so recommended by the manufacturer. Line-voltage power and interlock wiring conductors shall be sized in accordance with NEC.
- E. All wire insulation shall be color-coded and labeled for ease of identification.
- F. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines, with adequate support. Install without splices.
- G. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- H. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, liquid-tight, flexible metal conduits shall be used.
- I. Low-voltage (24V or less) AC or DC wiring shall not be run in conduit containing 120 VAC wiring.
- J. Inifinet Communication Wiring:
 - 1. Splicing is not acceptable.
 - 2. Label all junction boxes. Labels provided by the UCB HVAC Shop
- K. Label all temperature control wiring junction box covers with an adhesive backed water proof flexible Mylar label with the letters T/C using an orange background with black letters to differentiate them from junction boxes installed by the electrical and fire alarm contractor. The labels shall be 3" by 3".
- L. Use proper size wire nut type connectors on all sensor wiring. Crimp connectors are not allowed on sensor wiring.

3.05 ANDOVER CONTROLLERS

- A. I2920, I2810, I2850, I2800I (all Inifinet II (i2) controllers)
 - 1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
 - 2. Controller Power shall have a separate disconnect (or fuse) for each controller.
 - 3. All controllers will be connected for 24VAC, or 120V.
 - 4. All digital outputs will have a relay to operate the device
 - 5. Only Two pair of communication wires shall be connected to the communication terminal on the controller.
- B. Expansion Modules: Andover DDC
 - 1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
 - 2. The use of Andover DCC expansion Modules shall be pre-approved by the University HVAC Shop.
 - 3. Expansion modules can be used only with authorizations from HVAC shop.

C. Infilinks Installation

1. The Controls contractor shall follow the specifications shown in the Andover Hardware Installation Guide unless stated otherwise herein.
2. Extend existing InfiNet network for include new controller(s).

3.06 INSTALLATION AND SETUP REQUIREMENTS

A. Metal Oxide Varistors (MOV) on Outputs:

1. Install MOVs across all inductive loads being switched by an output from an Andover controller. This includes all relay coils, solenoid coils (E/Ps), etc. Install the MOV across the coil of the device. Use an MOV rated for the voltage of the coil.

B. Grounding the Shield on Communication Wiring:

1. The shield on communication wiring should be grounded in only one location per building. The connection point for the shield wire on LCX and SCX panels is not grounded. Connect the shield to this terminal on each panel just for consistency. The standard grounding location for each building shall be at the Infilink (see 3.03.C).
2. Tape any exposed shield wiring so that it cannot short-out on the Infilink housing or other source.

C. Splices in Communication Wiring:

1. Not allowed.

D. Setup of Setpoints

1. The Setpoint Box in the existing CX and Cyberstation software shall be checked for all numerical points to be used as setpoints or any type of constant value point.

E. Setup of Inputs

1. THRESHOLDS: The threshold shall be filled-in with the following value. Where a particular application is not listed, enter a reasonable value based on the application.
 - a. Temperature (Space, OAT, MAT, DAT, RAT, etc.) .1°F
 - b. Duct Static Pressure 0.2W.C.

F. Protect all points where pneumatic tubing or sensing elements come in contact with metallic surfaces by enclosing the tubing or sensor with a section of poly-tubing. This applies at such locations as duct penetrations, points where tubing is attached to ductwork, points where sensing elements come into contact with or are attached to coil frames, etc.

G. Seal all penetrations into ductwork or air-handling units with duct sealant or other means to make the installation airtight.

H. Mount all control valves so that the stem is vertical. Prior approval is required from the UCB HVAC Shop for all installations where this cannot be achieved.

I. Layout of Points on Controllers: The points on controllers shall be coordinated for approval by the UCB HVAC Shop.

3.07 CONTROL DEVICE LOCATIONS

A. Room thermostats and sensors shall be mounted 5'-0" above finished floor unless otherwise noted on drawings.

B. Remote control devices not in local panels shall be wall mounted at same level as thermostat.

- C. Locate all control devices wired by the Electrical Contractor under Division 16.

3.08 CONTROL PANELS

- A. Refer to Part 2 - Products for construction details.
- B. Field wiring shall be in conduit.
- C. Panels shall be wall-mounted at eye level for accessibility and service.
- D. Local control panels shall be located within same room of system served; otherwise location shall be approved by UCB HVAC Shop.
- E. Control devices shall be installed in panels. Relays shall be grouped together and installed in a single, central panel located next to the enclosure housing the associated controller. Remotely-mounted relays are not acceptable unless preapproved by HVAC Shop.
- F. Electrical power for each panel shall be from a dedicated circuit. Side-by-side panels may be served by the same circuit, with separate disconnect for each panel. Notify the Owner if the source is not from a dedicated circuit. Where available in a building, utilize emergency-power circuits for all controls.
- G. Mount panels on solid, non-vibrating surfaces. Where such surfaces are not readily accessible, mount the panel on a rigid, Unistrut stand attached to the floor. The sides of ducts and air-handling units are not acceptable mounting surfaces.

3.09 IDENTIFICATION

- A. All control equipment shall be clearly identified by HVAC shop drawing designation code and a functional description as follows:
1. Control valves: brass tags.
 2. Other remote control devices and sensors: metal tags; plastic laminate labels; or, on non-porous surfaces only, permanent label tape as produced by the Brother "Easy Touch" label maker. Do not attach tag or label to removable covers, etc. Rivet or stick to device or adjacent surface.
 3. Control panels: nameplate with panel number and systems served.
 4. Devices in control panels: engraved plastic tags; metal tags; or, on non-porous surfaces only, permanent label tape as above, mounted to panel adjacent to control device.
 5. All wiring, including wiring within factory-fabricated panels, shall be labeled within 2" of each termination with DDC point number/controller number or other descriptive information.
 6. When connecting DDC controllers, terminating of inputs and outputs shall be color coded as follows :
 7. 120VAC shall be black = hot, white = neutral, green = ground
 8. 24VAC shall be (+) black with white tracer, (-) white with black tracer
 9. 24VDC shall be (+) red with black tracer, (-) black with red tracer
 10. All pneumatic tubing shall be labeled within 2" of termination with a descriptive identifier.
 11. All metal and plastic engraved labels shall be secured with chains, nylon tie-wraps, or rivets. Permanent adhesive is acceptable only when mechanical fasteners would damage the labeled equipment.
 12. All switches, relays, and panel components shall be labeled.
 13. Labels shall not be mounted on removable surfaces, such as cable tray covers.

3.10 PROTECTION

- A. The Contractor shall protect all work and material from damage by his work or workmen, and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until finally inspected, tested, and accepted. He shall protect work against theft, injury, or damage; and shall carefully store material and equipment received on site which is not immediately installed. He shall close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.11 CLEANUP

- A. At the completion of work, all equipment on the project shall be checked and thoroughly cleaned including under equipment and any and all other areas around or in equipment provided under this section. Clean exposed surfaces of all equipment and panels of all grease, plaster, or other foreign material. Remove all stick-on labels and clean surfaces.
- B. At the completion of the work, remove from the building, the premises, and surrounding streets, alleys, etc., all rubbish and debris resulting from this project, and leave all equipment spaces clean and ready for use.
- C. At the completion of work, all equipment furnished under this contract shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet, jacket, or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.12 TESTING

- A. Prior to substantial completion, the control system shall undergo a series of tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his own performance tests.
- B. The tests described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process. Control system testing shall be coordinated with the HVAC Shop.
- C. The Contractor shall provide at least two men equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, summer, winter, occupied, unoccupied, fire/smoke alarm, and power failure modes. The purpose is to test the setup, calibration, response, and action of every point. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor. The Commissioning agent and the Owner's representative shall observe, direct and review these tests on site at controller panel / field location.
 - 1. The system software shall be complete such that each control loop shall function as specified in the Sequence of Operation and proper PID tuning. This Subcontractor shall be required to furnish the software program and test the operation of every control loop.
 - 2. After all field connections have been made and control power is available in the control panel, the Owner's representative shall be notified and the control system shall be energized. Any required reloading of the software shall be performed and commissioning of the mechanical system, automatic temperature control system, and other connected systems shall commence.
 - 3. This Subcontractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of

the specification. Control performance criteria are specified in the sequence of operations shown on the drawings and/or the specifications.

- D. Operational logs for each system which indicate all setpoints, operating points, valve/damper positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover a 24-hour period and have a sample frequency of not more than 10 minutes. The logs shall be provided in printed and digital media formats.
- E. Control loops shall maintain setpoint within the following tolerances:

Air Pressure	± 0.5 " w.g.	range 0-6" w.g.
	± 0.01 " w.g.	range -0.1 to 0.1" w.g.
Airflow	± 100 cfm	
Temperature	$\pm 1.0^{\circ}\text{F}$	

Control loops that do not meet the above tolerances shall be re-tuned.

- F. This Contractor shall demonstrate HVAC alarms prior to placing ventilation systems in service.
- G. The control systems will not be accepted as meeting the Requirements of Completion until all tests described in this section have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion Requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.
- H. After the system has operated properly for 90 days following startup of the final component of the heating and air conditioning systems, as-built copies of the software on electronic media and a printed copy shall be submitted to the Owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first year of operation is the responsibility of this Subcontractor. When changes are made to the software, the HVAC Shop must approve. The Contractor shall immediately provide updated copies of the files.

3.13 CONTROL EXECUTION - GENERAL

- A. This Contractor shall provide all required control interface relays, including any isolation relays required for interface to snorkel lights. All power wiring to snorkel lights by Division 16; all control function (interlock) wiring by the Controls Contractor.
- B. This Contractor shall be responsible for providing control power to all his controllers and devices requiring control power including installation of any required breakers, unless such wiring is shown on the Division 16 drawings.
- C. Accessibility: Install all control devices in readily accessible locations as defined by Chapter 1, Article 100, Part A of the NEC.
- D. All setpoints, operating points, sequencing ratios, PID tuning parameters, and all other numeric and digital constants shall be adjustable by the user (only with a high-level password) from the graphic. To change these values, the user shall not be required to modify program code, recompile, or download.
- E. Hand-Off-Auto switches shall energize equipment in both the 'hand' and 'auto' mode (when auto is commanded on for auto mode). Safeties shall protect equipment in the hand and auto

modes. Where fans are interlocked with damper end switches, the hand and auto positions shall open the dampers and the damper end switch shall energize the fan.

- F. System logs, trend logs, and event-initiated logs shall be set up to provide historical and real-time monitoring of system operation. Logs shall be grouped by equipment.
- G. Safety Shutdowns - General: All safety shutdowns of electrical equipment shall be hardwired. All shutdowns shall occur directly through interconnection of contacts on the safety device with the controlling circuit of the electrical equipment. Safety shutdowns through software are not acceptable. Interposing relays may be used only with prior approval of the Engineer and Owner's Representative when no alternative exists.
- H. This Contractor shall notify the University two weeks in advance of when connection to the BAS network will be beneficial to the system so the work can be scheduled.

3.14 WORKSTATION PROGRAMMING

- A. The University has multiple workstations networked across the campus. The main file server is located in the Facilities HVAC office in the Stadium Building. All graphics, alarms, trend logs, and schedules shall be accessible from any workstation and be fully integrated with existing menus.
- B. Graphics:
 - 1. The system shall be programmed by the Controls Contractor to provide a color graphic for:
 - a. Metal Smithing Room Ventilation System
 - b. Each VAV box with DDC controls
 - 2. Menu Penetrations: "Buttons" shall be provided to allow the user to easily move among the various graphics and menus. At any time, the operator shall be able to return to the main menu with one mouse click and shall switch from graphic to other modes within two mouse clicks.
- C. Alarm Setup:
 - 1. UCB personnel shall program all general equipment alarms not specified elsewhere in this section. Alarm programming will begin after the contractor has completed programming for all controllers and the new control system is on-line on the campus Andover network.
 - 2. The contractor shall allow full access to the control system by authorized UCB personnel for the purpose of programming alarms.
- D. Trend Logging:
 - 1. The system shall trend and display numerically and graphically any analog or digital points in the system.
 - 2. Trend logging and historical logging shall be programmed for all points and be fully operational.

3.15 DDC SOFTWARE

- A. Provide sufficient internal memory for the specified control sequences and logging. There shall be a minimum of 15% of available memory free for future use.

END OF SECTION 15950

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SECTION 15990 - WATER SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15512 - Valves (balancing valves)
- B. Section 15512 - Piping Specialties (flow measure devices)
- C. Section 15950 – Temperature Control System

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. TAB Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for balancing flow to reheat coils affected by the scope of work defined on the plans and as indicated on the equipment schedules. This work shall be completed without reducing the required flow to adjacent reheat coils and other heating devices on the same system.
- B. Approved Contractors:
 - 1. Checkpoint
 - 2. Finn & Associates
 - 3. TAB Services
 - 4. JPG Engineering
- C. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.
- D. Scope of work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected.
- E. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC or NEBB Standards, ASHRAE - 1999 HVAC Applications Chapter 36, and as detailed herein.
- F. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform Work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor who will submit it for approval.
- G. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including calibrated balancing valves, gauge tappings, flow sensors, and thermometer wells. Mechanical Contractor shall be responsible for trimming and balancing pump impellers as necessary to obtain design pump flow rates at the minimum pressure differential.
- H. TAB work shall not proceed until all assigned personnel have been approved by Owner/Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.04 SUBMITTALS

A. General:

1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless otherwise directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
2. Reports shall be assembled using 3-ring hard cover binder with project name and location on cover and side panel. Information sheets shall be 8-1/2" x 11" white bond paper. Use pre-printed forms of NEBB or AABC wherever possible. Provide numbered tabs for each system. Assemble report in the following order:
 - a. Transmittal letter.
 - b. Cover sheet with project title, location, submittal date, and name and addresses of Owner, Mechanical Contractor, TAB subcontractor, Architect, and Engineer.
 - c. Index of numbered tabs listing major systems.
 - d. Data organized by system in the following order:
 - 1). Equipment data and measurement summary.
 - 2). Equipment measurement data.
 - 3). Branch main measurement data.
 - 4). Terminal device measurement data.

B. Quality Assurance Submittal:

1. Within 30 days of signing Contract, Contractor shall submit the following information:
 - a. Firm resume:
 - 1). AABC or NEBB active membership Certificate.
 - 2). Names of 3 recent relevant completed projects along with project address, Owner's contact person, supervising design professional.
 - b. Supervisor resume.
 - c. Balance technician's resumes.
2. Architect/Engineer and/or Owner reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Owner feel are not qualified for this Project due to lack of relevant experience or problems on previous projects.

C. Planning Report:

1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Owner that proper procedures are being followed. Submit Planning Report after Quality Assurance submittal and 30 days before any fieldwork starts.

D. Initial Test Report:

1. Prior to starting Final Balance Phase, submit Initial Test Report as detailed in Part 3 of this Section to indicate to Architect/Engineer and Contractor incomplete work or problem areas to be resolved before final balance is completed.

E. Final Report:

1. Within 30 days after fieldwork is completed, submit Final Report as detailed in Part 3 of this Section to assure design objectives are met and to assist Owner in future maintenance.

F. Letter of approval of balancing devices provided by Mechanical Contractor.

1.05 REFERENCE STANDARDS

- A. Refer to the latest publications of NEBB, AABC and ASHRAE publications for establishing required procedures.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

- A. Provide required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.
- B. Instruments used for measurements shall be accurate, and calibration histories for each instrument shall be available for examination by Architect/Engineer upon request. Calibration and maintenance of all instruments to be in accordance with requirements of NEBB or AABC Standards.

PART 3 - EXECUTION

3.01 GENERAL

- A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.
- B. Unless otherwise specified, maximum acceptable offset tolerance shall be $\pm 10\%$ of design flow rates indicated on drawings and schedules.

3.02 PLANNING PHASE

- A. Procedure:
 - 1. Obtain the latest Contract Documents including addenda, construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for pumps, flow measuring devices, and terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.
- B. Planning Report:
 - 1. Planning Report shall contain the following minimum requirements.
 - 2. Narratives: Furnish written narratives of procedures to be used. Include separate narratives for each pump and liquid fluid handling system. Identify flow-measuring devices to be used at each pump and terminal device. Include different narratives for constant and variable flow systems. For non-standard water systems, include narratives on how to measure and adjust for different viscosities. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
 - 3. Prebalance Checklist: shall include, but not be limited to:
 - a. Check for completeness of work
 - b. Place system into operation
 - c. Set up of controls and control devices
 - 4. Measuring Instrument List: List that measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
 - a. Manufacturer name and model number
 - b. Measurement range
 - c. Pressure/temperature limits
 - d. Date put into service
 - e. Date of last calibration
 - f. Certificate from calibration firm
 - 5. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument that has not been recalibrated within past year.
 - 6. Samples: Submit copies of TAB Forms to be used.

7. Branch circuit and terminal measurements and adjustments: Indicate on pre-printed forms all measurements to be taken and adjustments to be made in field. Include branch circuit or terminal identification, system, space served, location, design flow rates (including zone and system summaries), and flow measuring device size, type, Cv, and manufacturer. Indicate the initial set points on forms.

3.03 SET-UP PHASE

- A. Procedure:
 1. Perform prebalance checkout as per Planning Phase narrative.
- B. Initial Test:
 1. Measure pump data and flow rates in "as found" condition after initial valve settings are made.
- C. Initial Test Report:
 1. Submit report to Architect/Engineer and Mechanical Contractor indicating measurements made and including notes of items that are not complete or are not within design tolerance.

3.04 FINAL BALANCE PHASE

- A. Procedure:
 1. Perform procedures as per Planning Phase narrative. Correct deficiencies and redo procedures as required prior to submitting Final Report.
- B. Final Report:
 1. Submit report to Architect/Engineer and to Mechanical Contractor indicating all data, measurements and adjustments as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.
- C. Final Report Adjustments:
 1. Architect/Engineer reserves the right to check any measurement or adjustment made and to reject any portion of Work not within specified tolerance. Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

END OF SECTION 15990

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SECTION 15991 - AIR SYSTEMS TEST ADJUST BALANCE

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 15900 - Ductwork
- B. Section 15910 - Ductwork Specialties (balancing devices)
- C. Section 15950 – Temperature Control System

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. This Contractor shall be responsible for providing complete testing, adjusting and balancing (TAB) work for air systems, such as air handling units, return fans, exhaust fans, air terminal devices, diffusers, grilles and other air moving processes included in this Project.
- B. Approved Contractors:
 - 1. Checkpoint
 - 2. Finn & Associates
 - 3. TAB Services
 - 4. JPG Engineering
- C. Work required shall consist of setting volume flow rates and adjusting speed controls, recording data, making tests, and preparing reports, as specified herein.
- D. Scope of Work includes TAB of new work specified herein and includes all equipment, distribution systems, and terminal units connected. This shall include but is not limited to:
 - 1. Determination of exhaust duct pressure setpoint required to maintain constant volume airflow required at hoods in Metal Smithing (290A). See Sheet M2.2A.
 - 2. Airflow balancing for all welding exhaust snorkels in Metal Shop (290) and Metal Smithing (290A).
- E. TAB work shall be performed by persons trained in TAB work and certified by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB). Procedures shall be in accordance with the latest edition of AABC or NEBB Standards, ASHRAE - 1999 HVAC Application Chapter 36, and as detailed herein.
- F. Mechanical Contractors who are members of AABC or NEBB and who have qualified personnel available to perform work may submit Quality Assurance Submittal for approval. Mechanical Contractors who cannot meet these requirements shall subcontract with independent TAB Contractor who meets these requirements. TAB subcontractor shall prepare Quality Assurance Submittal for Contractor to submit for approval.
- G. Upon direction of Architect/Engineer or TAB subcontractor, Mechanical Contractor shall provide at no additional cost to Owner, any additional work and/or devices necessary to properly balance system, including fan sheaves, motor sheaves and/or drive belts.
- H. TAB work shall not proceed until assigned personnel have been approved by Architect/Engineer via Quality Assurance Submittal. Coordinate each phase of TAB work with overall Project schedule. Each phase of TAB work shall be done in timely manner as detailed herein. Fieldwork must be

completed before occupancy. Certificate of Substantial Completion shall not be issued until after Final Report is accepted by Architect/Engineer.

1.04 SUBMITTALS

A. General:

1. Make submittals in accordance with project submittal procedure. Submit minimum of 5 copies of submittals unless more directed (3 for O&M Manuals, 1 for A/E, 1 for Contractor).
2. Reports shall be assembled using 3-ring hard cover binder with Project Name and location on cover and side panel. All information sheets shall be 8-1/2" x 11" white bond paper. Use preprinted forms of NEBB or AABC wherever possible. Provide numbered tabs for each system. Assemble report in the following order:
 - a. Transmittal letter
 - b. Cover sheet with Project title, location, submittal date, and name and addresses of Owner, Mechanical Contractor, TAB subcontractor, Architect, and Engineer.
 - c. Index of numbered tabs listing major systems.
 - d. Data organized by system in the following order:
 - 1). Equipment data and measurement summary
 - 2). Equipment measurement data
 - 3). Branch main measurement data
 - 4). Terminal device measurement data

B. Quality Assurance Submittal:

1. Within 30 days of signing Contract, Contractor shall submit the following information:
 - a. Firm resume:
 - 1). AABC or NEBB active membership Certificate.
 - 2). Names of 3 recent relevant completed projects along with project address, Owner's contact person, supervising design professional.
 - b. Supervisor resume.
 - c. Balance technician(s) resume.
2. Architect/Engineer and/or Owner reserves the right to contact previous project representatives and to reject persons whom Architect/Engineer and/or Owner feel are not qualified for this Project due to lack of relevant experience or problems on previous projects.

C. Planning Report:

1. Submit Planning Report as detailed in Part 3 of this Section to demonstrate to Architect/Engineer and Owner that proper procedures are being followed. Planning Report shall be submitted after Quality Assurance submittal and 30 days before any fieldwork starts.

D. Initial Test Report:

1. Prior to starting Final Balance Phase, submit Initial Test Report as detailed in Part 3 of this Section to indicate to Architect/Engineer and Contractor incomplete work or problem areas to be resolved before final balance is completed.

E. Final Report:

1. Within 30 days after fieldwork is completed, submit Final Report as detailed in Part 3 of this Section to assure design objectives are met and to assist Owner in future maintenance.

F. Letter of approval of balancing devices provided by Mechanical Contractor.

1.05 REFERENCE STANDARDS

- A. Refer to the latest publications of NEBB, AABC, ASHRAE, and Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Publications for establishing required procedures.

PART 2 - PRODUCTS

2.01 INSTRUMENTATION

- A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of NEBB or AABC Standards and instrument manufacturer's specifications.
- B. Instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of instruments to be in accordance with requirements of NEBB or AABC Standards.

2.02 INSTRUMENT TEST HOLE PLUGS

- A. Center-pull plugs similar to Alliance Plastics CP Series. Plug material shall be Grade 1 virgin polyethylene.

PART 3 - EXECUTION

3.01 GENERAL

- A. TAB work shall be done in separate phases as outlined herein. TAB schedule shall allow ample time to complete TAB work before occupancy. Follow procedures outlined herein and as described in Planning Phase narratives.
- B. Unless otherwise specified, maximum acceptable offset tolerance is plus or minus 10% of the design flow rates as indicated on drawings and/or as scheduled.

3.02 PLANNING PHASE

- A. Procedure:
 - 1. Obtain the latest Contract Documents including addenda, applicable construction bulletins and change orders. Obtain shop drawings and performance curves from Mechanical Contractor for fans, flow measuring devices, and all terminal devices. Prepare Planning Report as detailed herein. Make adjustments in Planning Report and/or measuring instrument calibration.
- B. Planning Report:
 - 1. Planning Report shall contain the following minimum requirements.
 - a. Samples: Provide copies of all forms to be used.
 - b. General narratives: Furnish written narratives of all procedures used. Include separate narratives for each fan and air handling system. Identify flow-measuring devices to be used at each fan, air terminal device, and air outlet. Narrative shall include statement that every air outlet shall be measured and adjusted. Provide different narratives for constant and variable flow systems. Narratives shall include references to published standards of NEBB or AABC. Narratives shall include measuring instruments to be used and ranges required for each procedure. Narratives shall include specified adjustment tolerances.
 - c. Air system narratives: Provide narratives for each air system which shall include procedures for measuring static pressures at each component of air handling system to generate a static pressure profile. Measurements shall be made to measure performance of system in all operating modes including economizer mode using 100% outside air where applicable. Differentiate between constant and variable flow systems.
 - d. Non-standard air system narratives: Include narratives on how to measure and adjust for different air densities for systems with static pressures greater than 8" WG or temperatures greater than 140°F.
 - e. Air terminal narratives: Narratives shall describe procedures for measuring flows and adjusting controls to meet specified minimum and maximum flow rates based on actual field installed conditions.
 - f. Branch duct and air outlet measurements: Indicate on preprinted forms all measurements to be taken in field. Include branch duct or air outlet identification, system, space served,

location, and design flow rates (include zone and system summaries). Indicate duct or air outlet neck size, make, model number, Ak factor, and design velocities.

- g. Pressure relationship test narrative: Narratives shall describe how to obtain and measure pressure relationships between spaces as per schedule or as listed below:
 - 1). Laboratories
 - 2). Art galleries
2. Prebalance Checklist - to include, but not limited to:
 - a. Check for completeness of work.
 - b. System cleaning if required.
 - c. Check fire, smoke and balancing damper positions.
 - d. Place system into normal operation.
 - e. Install test openings where required.
 - f. Indicate type of test holes to be used and installation procedure.
 - g. Note condition of filters.
 - h. Chisel holes and duct tape are not allowed.
 - i. Fan wheels, blades, bearings, alignment, starters, vibration isolators, and rotation.
 - j. Drive belt tension and alignment.
 - k. Setting of automatic dampers to proper position.
 - l. Set up of controls and control devices.
3. Measuring Instrument List - list what measuring instruments will be used for each procedure. Indicate ranges required for each procedure. Provide data on each measuring instrument to be used. This data shall include:
 - a. Manufacturer name and model number.
 - b. Measurement range.
 - c. Pressure/temperature limits.
 - d. Date put into service.
 - e. Date of last calibration.
 - f. Include certificate from calibration firm.
4. Architect/Engineer reserves the right to request adjustments in any procedure and/or ask for recalibration of any measuring instrument, which has not been recalibrated within past year.

3.03 SET-UP PHASE

- A. Procedure:
 1. Perform prebalance checkout as per Planning Phase narrative.
- B. Initial Test:
 1. Measure fan data and flows in "as found" condition after initial damper settings are made.
- C. Initial Test Report:
 1. Submit report to Architect/Engineer and Mechanical Contractor indicating all measurements made and make notes of all items, which are not complete or are not within design tolerance.

3.04 FINAL BALANCE PHASE

- A. Procedure:
 1. Perform all procedures as per Planning Phase narrative. Correct all deficiencies and redo procedures as required before submitting Final Report.

B. Final Report:

1. Submit report to Architect/Engineer and Mechanical Contractor indicating all data and measurements as per requirements herein and per Planning Phase narrative. Do not submit partial or incomplete reports.

C. Final Report Adjustments:

1. Architect/Engineer reserves the right to check any measurement made and to reject any portion of work not within required tolerance of design flow. TAB Contractor shall resubmit all or portions of Final Report as directed by Architect/Engineer.

END OF SECTION 15991

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SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.02 DESCRIPTION

- A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.
- B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 16 Contract Documents shall have the following meanings:
 - 1. "Provide" or "provided" shall mean "furnish and install".
 - 2. "Furnish" or "furnished" does not include installation.
 - 3. "Install" or "installed" does not include furnishing.
- C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
- D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.
- E. Included in this Contract are electrical connections to equipment provided by others. Refer to Mechanical, and final shop drawings for equipment being furnished under other sections for exact locations of electrical connections required.
- F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.
- G. All Work shall be performed in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.03 RELATED WORK

- A. Utility Services:
- B. Continuity of Service:
 - 1. No service shall be interrupted or changed without permission from Architect and Owner. Obtain written permission before any work is started.
 - 2. When interruption of services is required, all persons concerned shall be notified and shall agree upon a time.
- C. Painting:
 - 1. Painting of electrical equipment will be done under Division 9 unless specified otherwise or is to be furnished with factory applied finish coats.
 - 2. Furnish equipment with factory applied prime finish unless otherwise specified.
 - 3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
 - 4. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.

1.04 REQUIREMENTS OF REGULATORY AGENCIES

- A. Rules and regulations of Federal, State and Local Authorities and utility companies, in force at time of execution of Contract shall become part of this Specification.

1.05 REFERENCE STANDARDS

- A. Agencies or publications referenced herein refer to the following:
 1. AEIC Association of Edison Illuminating Companies
 2. ANSI American National Standards Institute
 3. ASME American Society of Mechanical Engineers
 4. ASTM American Society for Testing and Materials
 5. BICSI Building Industry Consulting Services International
 6. EIA Electronic Industries Association
 7. FIPS Federal Information Processing Standards
 8. FCC Federal Communications Commission
 9. ICEA Insulated Cable Engineers Association
 10. IEEE Institute of Electrical & Electronics Engineers
 11. IESNA Illuminating Engineering Society of North America
 12. NEC National Electrical Code
 13. NECA National Electrical Contractors Association
 14. NEMA National Electrical Manufacturers Association
 15. NESC National Electrical Safety Code
 16. NETA National Electrical Testing Association
 17. NFPA National Fire Protection Association
 18. NIST National Institute of Standards & Technology
 19. OSHA Occupational Safety and Health Administration
 20. TIA Telecommunications Industries Association
 21. UL Underwriters Laboratories, Inc.
- B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.06 LISTING

- A. All material installed on Project shall bear UL label or be UL listed, unless UL label or listing is not available for that type of material.
- B. Other nationally recognized testing agencies, acceptable to AHJ, are approved.

1.07 ENCLOSURES

- A. Typical NEMA Enclosures and Usage
 1. NEMA 1 - Indoors. Falling dirt.
 2. NEMA 2 - Indoors. Falling dirt. Falling liquids. Light splashing.
 3. NEMA 3 - Outdoors. Sleet, snow, rain. Windblown dust.
 4. NEMA 3X - Same as NEMA 3 plus corrosion resistant.
 5. NEMA 3S - Same as NEMA 3 plus mechanism operable when ice covered.
 6. NEMA 3SX - Same as NEMA 3S plus corrosion resistant.
 7. NEMA 3R - Outdoors. Rain, snow, sleet.
 8. NEMA 3RX - Same as NEMA 3R plus corrosion resistant.
 9. NEMA 4 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down.
 10. NEMA 4X - Same as NEMA 4 - Indoors plus corrosion resistant.

11. NEMA 4 - Outdoors. Rain, sleet, snow. Wind blown dust. Hose down.
12. NEMA 4X - Same as NEMA 4 - Outdoors plus corrosion resistant.
13. NEMA 5 - Indoors. Falling Dirt. Falling Liquids. Settling dust, lint and fibers.
14. NEMA 6 - Indoors. Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down. Temporary submersion.
15. NEMA 6P - Same as NEMA 6 - Indoors plus corrosion resistant. Prolonged submersion.
16. NEMA 6 - Outdoors. Rain, snow, sleet. Windblown dust. Hose down. Temporary submersion.
17. NEMA 6P - Same as NEMA 6 - Outdoors plus corrosion resistant. Prolonged Submersion.
18. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
19. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
20. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.
21. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.

1.08 SUBMITTALS

- A. Submit Shop Drawings for equipment provided under this Section:
 1. Refer to Section 01300 – Submittals, Shop Drawings, Product Data, and Samples.
 2. Note that for satisfying submittal requirements for Division 16, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Section 01330. However, the expression "Shop Drawings" is generally used throughout Specification.
 3. Submit shop drawings for equipment and systems as requested in the respective Specification sections. Submittals which are not requested may not be reviewed.
 4. Mark general catalog sheets and drawings to indicate specific items submitted.
 5. Include proper identification of equipment by name and/or number, as indicated in Specification and shown on drawings.
 6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Submittals shall be clearly marked and noted accordingly.
 7. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include all required components.
 8. Include wiring diagrams for all electrically powered or controlled equipment.
 9. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
 10. Submit shop drawings or product data as soon as practicable after signing Contracts. Submittals must be approved before installation of materials and equipment.
 11. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
- B. Certificates and Inspections:
 1. Obtain and pay for inspections required by Authorities Having Jurisdiction and deliver certificates approving installations to Owner unless otherwise directed.
- C. Record Documents:
 1. Refer to General Conditions of Contract, and Section 01700 – Contract Close-out. Prepare complete set of record drawings in accordance with Section 01770.
 2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.09 JOB CONDITIONS

- A. Building Access:
 1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Coordination:

1. Equipment provided under other Divisions of these Specifications:
 - a. Motors
 - b. Electrically powered equipment
 - c. Electrically controlled equipment
 - d. Starters, where specified
 - e. Variable frequency drives
 - f. Control devices, where specified
 - g. Temperature Control wiring
2. This Contractor shall provide, unless noted otherwise:
 - a. Starters
 - b. Disconnect devices
 - c. Control devices:
 - 1). Pushbuttons
 - 2). Pilot lights
 - 3). Contacts
 - d. Power wiring
 - e. Control wiring, except temperature control wiring.
3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
4. Where starters or other devices are furnished, by others they shall be connected and wired by this Contractor.
5. This Contractor's drawings and/or specifications shall show number and HP rating of motors furnished by others, together with their actuating devices. Should any change in size, HP rating or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be the responsibility of Contractor initiating the change.
6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
7. Motors shall be furnished by others for starting in accordance with local utility requirements and shall be compatible with starters as specified herein or under various trade sections of these Specifications.

C. Cutting and Patching:

1. Refer to General Conditions of the Contract, and Section 01045 - Cutting and Patching.
2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore all work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
3. Provide all materials required for patching unless otherwise noted.
4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

D. Housekeeping and Cleanup:

1. Refer to Section 01700 – Contract Close-out.
2. Periodically as Work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of Work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.10 GUARANTEE

- A. Guarantee for one year after acceptance by Owner all equipment, materials, and workmanship to be free from defect.
- B. Repair, replace or alter systems or parts of systems found defective at no extra cost to Owner.
- C. In any case, wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another Contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other Contract.

PART 2 - PRODUCTS

2.01 PRODUCT SUBSTITUTIONS

- A. Refer to Section 01600 - Product Requirements.

PART 3 - EXECUTION

3.01 GENERAL

- A. Verify elevations and measurements prior to installation of materials.

3.02 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the site under provisions of Division 1.
- B. Store and protect products under provisions of Division 1.
- C. Store in a clean, dry space.
- D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with manufacturer's written instructions.
- F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.03 FLOOR, WALL, ROOF AND CEILING OPENINGS

- A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors.
- B. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.
- C. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.
- D. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 16073.
- E. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.
- F. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

- G. Seal non-rated wall openings with urethane caulk.
- H. Finish and trim penetrations as shown on details and as specified hereinafter.

3.04 EQUIPMENT ACCESS

- A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access shall be provided at no additional cost to Owner.
- B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.

3.05 EQUIPMENT SUPPORTS

- A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.
- B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.
- C. Do not support equipment or luminaires from metal roof decking.

3.06 SUPPORT PROTECTION

- A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.
- B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.
- C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.07 START-UP

- A. All systems and equipment shall be started, tested, adjusted and turned over to Owner ready for operation.
 - 1. This includes "Owner-Furnished, Contractor-Installed" (OFICI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.
- B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.
- C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and checkout of types of systems and equipment on Project.
- D. Provide start-up services, by manufacturer's representative where specified or where Contractor does not have qualified personnel.
- E. Coordinate start-up with all trades.

3.08 CLEANING

- A. After installation is complete, Contractor shall clean all systems.
- B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.

- C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

END OF SECTION 16010

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SECTION 16073 - ELECTRICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16010 - Basic Electrical Requirements
- B. Section 16110 - Raceways

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 - General Requirements.

1.03 DESCRIPTION

- A. Furnish and install work under this Section including the following:
 1. Penetrations through fire-resistance-rated floor, roof, walls and partitions including openings containing conduits, cables, cable bundles, cable tray and other penetrating items.
 2. Firestopping systems and installation shall provide fire rating equal to that of construction being penetrated.
 3. Proposed firestop materials and methods shall conform to applicable Code requirements of Authority Having Jurisdiction.

1.04 REFERENCE STANDARDS

- A. U.L. 1479 - Fire Tests For Through-Penetration Firestops.
- B. U.L. 2079 - Tests For Fire Resistance of Building Joint Systems.

1.05 SUBMITTALS

- A. Submit Shop Drawings for equipment provided under this Section.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has completed firestopping systems that are similar in material, design and extent to that indicated for this Project and that have performed successfully.
- B. A manufacturer's representative shall be on-site during initial installation of firestop systems to train appropriate contractor personnel in proper selection and installation procedures.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. 3M, Hilti, Tremco, Nelson Firestop Products, Specified Technologies, Inc, or Rectorseal Corp.

2.02 MATERIALS

- A. Use only firestop products that have been UL tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance.
- B. Materials shall not contain flammable solvents.
- C. Use removable pillow type fire stop material with cable tray.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PROJECT CONDITIONS

- A. Do not install firestopping when ambient or substrate temperatures are outside limits permitted by firestopping manufacturer or when substrates are wet due to rain, frost, condensation or other causes.
- B. Ventilate firestopping per manufacturers' instructions by natural means or, where this is inadequate, forced air circulation.

3.03 DELIVERY AND HANDLING

- A. Deliver products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and UL Label where applicable.
- B. Handle with recommended procedures, precautions or remedies described in material safety data sheets as applicable.

3.04 PREPARATION

- A. Clean out openings immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer.
- B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
- C. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.05 INSTALLATION

- A. Comply with manufacturer's installation instructions and drawings.
- B. Install forming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials, remove forming materials and other accessories not indicated as permanent components of firestop systems.
- C. Avoid multiple penetrations of common fire barrier opening. When possible, seal each penetration in accordance with project details.

3.06 SEQUENCING AND SCHEDULING

- A. Do not cover up firestopping installations that will become concealed behind other construction until Authorities Having Jurisdiction, if required, have examined each installation.
- B. Where deficiencies are found, repair or replace firestopping so that it complies with requirements.

3.07 CLEANING

- A. Clean surfaces adjacent to sealed holes and joints free of excess firestop materials and soiling as Work progresses.

END OF SECTION 16073

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SECTION 16110 - RACEWAYS

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16073 - Electrical Systems Firestopping
- B. Section 16120 – Wire and Cable
- C. Section 16195 - Electrical Identification

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. This Section includes raceways, fittings, pull and junction boxes, and raceway seals.

1.04 REFERENCE STANDARDS

- A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
- B. ANSI C80-1 - Rigid Steel Conduit-Zinc Coated (GRS)
- C. ANSI C80-3 - Electrical Metallic Tubing-Zinc Coated (EMT)
- D. ANSI C80-6 - Intermediate Metal Conduit-Zinc Coated (IMC)
- E. ASTM A 53/A 53M - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
- H. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
- I. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
- J. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
- K. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit
- L. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing
- M. NEMA TC 13 - Electrical Nonmetallic Tubing (ENT)
- N. NFPA 70 - National Electrical Code
- O. UL 1 - Flexible Metal Conduit
- P. UL 6 - Electrical Rigid Metallic Conduit-Steel
- Q. UL 6A - Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel
- R. UL 360 - Liquid-Tight Flexible Steel Conduit

- S. UL 514A - Metallic Outlet Boxes
- T. UL 514B - Conduit, Tubing, and Cable Fittings
- U. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
- V. UL 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings
- W. UL 797 - Electrical Metallic Tubing-Steel
- X. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings
- Y. UL 1242 - Electrical Intermediate Metal Conduit-Steel
- Z. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit
- AA. UL 2024 - Optical Fiber and Communication Cable Raceway

1.05 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with NFPA 70.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Protect PVC conduit from sunlight.
- C. Comply with manufacturer's written instructions.

1.07 WARRANTY

- A. Manufacturer shall provide standard one-year written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.01 ELECTRICAL METALLIC TUBING (EMT)

- A. ANSI C80.3, UL 797; galvanized steel tubing.
- B. Conduit bodies cover: steel, with stainless steel screws and neoprene gaskets. Indentor, drive-on, die-cast or pressure cast fittings not permitted.
- C. Fittings Manufacturers: Same as manufacturers listed in 2.1.F.

2.02 FLEXIBLE METAL CONDUIT (FMC)

- A. UL 1; interlocked steel.
- B. Fittings: NEMA FB I, UL 514B; steel.

2.03 LIQUID-TIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. UL 360; interlocked steel, with PVC jacket.

- B. Fittings: NEMA FB 1, UL 514B; steel.

2.04 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel.
- B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; galvanized, cast iron with ground flange, gasketed cover and stainless steel cover screws.
- C. Minimum size: 4" square by 2-1/8" deep for use with 1" conduit and smaller; 4-11/16" square by 2-1/8" deep for use with 1-1/4" conduit and larger.
- D. Sheet Metal Boxes larger than 12" in any direction: Hinged cover or a chain installed between box and cover.
- E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.
- F. Manufacturers: same as manufacturers listed in 2.14.E.

2.05 EXPANSION FITTINGS

- A. Malleable iron, hot dip galvanized allowing 4" (+/-2") raceway movement.
- B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.F.

2.06 RACEWAY PENETRATION SEALS

- A. Thruwall and Floor Seals.
- B. Manufacturers: New construction - OZ/Gedney FSK Series; existing construction - OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.F.

2.07 RACEWAY SEALING FITTINGS

- A. For 1 through 4 conductors: Manufacturers: OZ/Gedney CSB Series.
- B. For greater than 4 conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound.
- C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound.

2.08 CABLE SUPPORTS

- A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.F.

2.09 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Sleeves for Rectangular Openings: galvanized sheet steel with minimum 0.052" or 0.138" thickness and of length to suit application.

PART 3 - EXECUTION

3.01 COORDINATION

- A. Coordinate routing of through-roof conduits.
- B. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 16073 - Electrical Systems Firestopping.

- C. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.
- D. Verify with manufacturer that "touch-up" paint kit and PVC-coating kit are available for use.

3.02 EXAMINATION

- A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway's installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Raceways:

1. Comply with ANSI/NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
2. Arrange raceways to maintain headroom and present a neat appearance.
3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
4. Keep raceways at least 12" away from parallel runs of flues and steam or hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6 ft-6" minimum headroom, except in exit pathways 7 ft-0" minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.
6. Avoid exposed raceway runs. Run raceways exposed where it is impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel or perpendicular to construction. Do not route exposed raceways over boilers or other high-temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.
7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.
8. Cut raceways square using a saw or pipe cutter.
9. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 2", unless sweep elbows are required. Bend raceways according to manufacturer's recommendations. Do not use torches or open flame to aid in bend of PVC conduit.
10. Use raceway fittings compatible with raceways and suitable for use and environment.
11. Provide bushings on all raceways 1-1/2" and larger.
12. Raceways minimum sizes:
 - a. Minimum raceway size 3/4", except as noted on drawings.
 - b. Minimum home run size: 1", except as noted on drawings.
 - c. Minimum size for flexible metal conduit is 1/2" except 3/8" for luminaires.
 - d. Minimum size for liquid tight flexible metal conduit is 1/2".
13. Install empty raceways 2-1/2" and larger with No. 10 galvanized fish wire; install nylon pull cord in raceways smaller than 2-1/2"; leave at least 12" of slack at each end of pull wire.
14. Feed devices in exterior or load-bearing walls by horizontal conduit runs. Install horizontal conduit runs from device to device on same wall. Do not install horizontal bends in conduit around corners. Feed devices on the same wall vertically from above or junction box in suspended ceiling.
15. Raceways Supports:
 - a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
 - b. Raceway supports for horizontal or vertical single runs:
 - 1). Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.
 - 2). Spring steel type pressure clamps for raceways 3/4" and smaller.

- c. Raceway supports for horizontal and vertical multiple runs:
 - 1). Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.
 - 2). Support horizontal runs with appropriately sized rods.
 - 3). Anchor vertical runs to structure.
 - 4). Spring-steel type pressure clamps for raceways 3/4" and smaller.
 - d. Vertical raceway runs 1-1/4" and larger passing through floors shall be supported at each floor with pipe riser clamps.
 - e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.
 - f. Secure raceways in metal stud walls, to prevent rattling.
 - g. Arrange raceway supports to prevent misalignment during wiring installation.
 - h. Do not fasten raceways to corrugated metal roof deck.
16. Identify raceways per requirements in Section 16195 - Electrical Identification.
17. Flexible Conduit Connections: Use maximum of 72" of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
- a. Use LFMC in damp or wet locations subject to severe physical damage.
 - b. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- B. Boxes:
- 1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
 - 2. Install the appropriate cover on surface-mounted boxes:
 - a. Raised device covers on 4" square and 4-11/16" boxes and handy box covers on handy boxes, etc.
 - b. Device covers that are square drawn or square cut on boxes in block.
 - c. Tile covers on boxes in tile.
 - d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
 - e. Set front edge of device boxes flush with the finished wall surfaces except on walls of non-combustible materials where the boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
 - 3. Set outlet boxes parallel to construction and independently attached to same.
 - 4. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls.
 - 5. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
 - 6. Box Support:
 - a. Mount boxes straight.
 - b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
 - c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
 - d. Do not support boxes with tie-wire.
 - e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
 - f. Support boxes independently of raceways.
 - g. Install adjustable steel channel fasteners for hung ceiling outlet box.
 - h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
 - i. Do not install boxes to ceiling support wires or other piping systems.

7. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
 8. Pull and junction boxes: install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
 9. Install boxes to be permanently accessible.
 10. Do not intermix conductors from one system in same junction box or pull box unless shown or specifically authorized otherwise.
 11. Adjust box location up to 10 ft prior to rough-in to accommodate intended purpose.
 12. Inaccessible Ceiling Areas: install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
 13. Drawings do not necessarily show every outlet, pull or junction box required. Add required boxes, as necessary.
- C. Expansion Fittings:
1. Install raceway expansion and deflection fittings in raceway runs imbedded in or penetrating concrete where movement perpendicular to axis of raceway may be encountered.
 2. Install raceway expansion fittings complete with bonding jumpers in raceway runs, which cross expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
 3. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
 4. Install fitting(s) that provide expansion and contraction for at least 0.00041" per ft of length of straight run per deg F of temperature change.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation.
- D. Raceway Penetration Seals:
1. Exterior wall surfaces above grade: install watertight seal around raceways. For concrete construction above ground level, cast raceway in wall or core drill wall and hard pack with mixture of equal parts sand and cement. For other types of construction, use method acceptable to Architect.
 2. Exterior surfaces below grade: provide watertight seal around all raceways. Cast raceway into wall (or floor) or use manufactured seal assembly.
 3. Roofs: install flashed and hot mopped weatherproof seal, or pitch pan filled and sealed to be weatherproof where raceway penetrates roof membrane. Install weatherhead on raceway stubups penetrating roof.
 4. Fire-rated construction: seal penetrations to maintain fire rating of construction penetrated. Refer to requirements in Section 16073 - Electrical Systems Firestopping.
- E. Raceway Ceiling Fittings:
1. Install listed watertight seals to prevent passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of building, where raceway passes between areas of different temperatures such as into or out of cold rooms or freezers, where raceway enters room which at any time is low or high temperature room and where raceway enters room which at any time is subject to internal air pressures above or below normal.
 2. Install watertight seals in interior of raceways passing through building roof, ground floor slab (when raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on end inside building, using raceway sealing fittings manufactured for purpose. Locate fittings at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank cover plate to match finish of adjacent plates or surfaces.
 3. Seal raceways entering or passing through areas that are "hazardous (classified) areas" as defined in NFPA 70.
- F. Sleeve Installation for Electrical Penetrations:
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 16073 - Electrical Systems Firestopping.

2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50" and no side greater than 16", thickness shall be 0.052".
 - b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50" and 1 or more sides equal to, or greater than, 16", thickness shall be 0.138".
5. Fire-Rated Assemblies: install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2" above finished floor level.
8. Size pipe sleeves to provide 1/4" annular clear space between sleeve and raceway unless sleeve seal is to be installed.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
11. Fire-Rated-Assembly Penetrations: maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 16073 - Electrical Systems Firestopping.
12. Roof-Penetration Sleeves: seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
13. Aboveground, Exterior-Wall Penetrations: seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground, Exterior-Wall Penetrations: install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1" annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.04 APPLICATION

- A. Raceway uses permitted and not permitted per NFPA 70 requirements and as described below.
- B. Electrical Metallic Tubing (EMT) permitted to be installed as follows:
 1. Interior partitions.
 2. Above suspended ceilings.
 3. 6 ft AFF in exposed areas of mechanical equipment rooms.
- C. Flexible Metal Conduit (FMC) permitted to be installed as follows:
 1. Use flexible metal conduit not over 3 ft in length for final connections for:
 - a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in dry locations.
 - b. Final connections to recessed luminaires in lengths not to exceed 6 ft.
 2. No flexible metal conduit length restriction when using "Manufactured Wiring Systems."
- D. Liquid Tight Flexible Metal Conduit (LFMC) permitted to be installed as follows:
 1. Use liquid tight flexible conduit, not over 3 ft in length, for final connections to:
 - a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in wet locations.
 - b. Instruments and control devices.
 - c. Final connection to all sprinkler and preaction valves.

- E. 1/2" Raceway permitted:
 - 1. Between starter and its control or pilot device.
 - 2. Between lighting switch and nearest outlet for luminaire.
 - 3. Control wiring where mounted on equipment where conduit must follow contour of equipment.
 - 4. Protective and signal systems where noted.
 - 5. Where shown on plans.

3.05 RACEWAY WIRING METHODS

- A. Concealed Dry Locations: install electrical metallic tubing; install sheet-metal boxes; install flush mounting outlet boxes in finished areas; install hinged enclosure for large pull boxes.
- B. Exposed Dry Locations: install sheet-metal boxes; install flush mounting outlet box in finished areas; install hinged enclosure for large pull boxes. All surface conduits shall be painted to match surrounding walls.

3.06 FIELD QUALITY CONTROL

- A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.
- B. Replace any damaged component of the raceway system, or install new raceway system.
- C. Inspect components, wiring, connections and grounding.

3.07 REPAINTING

- A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner.
- B. Remove damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner.
- C. Wireways, indoor service poles: remove paint splatters and other marks from surface; touch-up chips, scratches, or marred finished to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.08 ADJUSTING

- A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
- B. Install knockout closures in unused openings in boxes.
- C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
- D. Adjust outlet boxes to allow luminaires to be positioned as indicated on reflected ceiling plan.

3.09 CLEANING

- A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

END OF SECTION 16110

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SECTION 16120 - WIRE AND CABLE

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16010 - Basic Electrical Requirements
- B. Section 16110 - Raceways
- C. Section 16195 - Electrical Identification

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. Conductor and conduit sizes in these Contract Documents are based on copper wire, and only copper wire shall be used.

1.04 REFERENCE STANDARDS

- A. UL83 - Thermoplastic - Insulated Wires and Cables.
- B. UL44 - Rubber-Insulated Wires and Cables.
- C. UL486A - Wire Connectors and Soldering Lugs for use with Copper Conductors.
- D. UL4868 - Wire Connectors for use with Aluminum Conductors.
- E. UL486C - Splicing Wire Connectors.
- F. UL1569 - Metal-clad cable.

PART 2 - PRODUCTS

2.01 FABRICATION AND MANUFACTURER

- A. Conductors for use at 600 volts or below shall have 600 volt rated insulation.
 - 1. Wire No. 12 and smaller may be solid.
 - 2. Wire No. 10 and larger shall be stranded only.
 - 3. Provide stranded conductors where conductors terminate in crimp type lugs.
- B. Motor circuit branch wiring and associated control wiring:
 - 1. Type THHN insulation.
 - 2. Motor wiring to be stranded copper.
- C. Branch Circuit Wiring:
 - 1. Use Type THHN, THW-2, THWN-2 or XHHW-2 insulation.

PART 3 - EXECUTION

3.01 SEQUENCING-SCHEDULING

- A. Do not pull wire in until building is enclosed and weather tight.

3.02 INSTALLATION

- A. Color code power wiring as follows:
 - 1. 208Y/120 volt, 3-phase, 4-wire: Phase A-black, Phase B-red, Phase C-blue, neutral-white ground conductor-green.
 - 2. 480Y/277 volt, 3-phase, 4-wire: Phase A-brown, Phase B-orange, Phase C-yellow, neutral-gray ground conductor-green.
- B. Pull wire and cables into conduits and raceways in such manner that insulation will not be damaged or undue strain placed on conductors.
 - 1. Lubricants shall be UL Listed.
- C. Branch circuit wires in panels shall be neatly arranged with surplus wire cut off and wires tied with non-metallic ties.
 - 1. Metallic ties not permitted.
- D. Conductors shall be attached to terminal screw or lug per UL Listing.
- E. Joints, taps and splices sizes No. 10 and smaller:
 - 1. Ideal-Nut Connectors or Scotchlok Spring connectors.
- F. Joints, taps and splices sizes No. 8 and larger:
 - 1. Aluminum/copper compression connectors.
 - a. Install with hydraulic compression tool.
- G. Joints, taps and splices sizes larger than No. 1:
 - 1. Tape with electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half lapped layers of plastic electrical tape.
- H. Plastic snap-on splice insulators are not allowed.
- I. Support conductors in vertical raceways using OZ type "S" cable supports for 600 volt conductors.
- J. Support conductors above 600 volts in vertical raceways using OZ type "R" cable supports.

3.03 APPLICATION

- A. Minimum conductor sizes shall be as follows:
 - 1. No. 12 - Branch circuits of any kind.
 - 2. No. 14 - Signal systems, fire alarm system.
 - 3. No. 10 - Exit light circuits, emergency circuits, security lighting.
- B. Limit conduit fill to a maximum of 9 current carrying conductors.

3.04 BRANCH WIRING

- A. 208Y/120 volt circuits over 75 ft in length: Increase wire size one size for each 75 ft of length. Increase conduit size as required.
- B. 480Y/277 volt circuits over 150 ft in length: Increase wire size one size for each 150 ft of length. Increase conduit size as required.

END OF SECTION 16120

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SECTION 16190 - SUPPORTING DEVICES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16010 - Basic Electrical Requirements
- B. Section 16110 - Raceways

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and section under Division 1 General Requirements.

1.03 DESCRIPTION

- A. Provide all supporting devices as specified and as required for proper support of conduit and electrical equipment.
- B. Provide all supporting steel, not indicated on structural drawings, that is required for installation of Electrical equipment and materials, including angles, channels, beams, etc. to suspend on floor support equipment.
- C. Support for all conditions of operation to prevent excess stress and allow for proper expansion and contraction.
- D. Conduit clamps, straps, supports, etc., shall be steel or malleable iron. One-hole straps shall be heavy duty type. All straps shall have steel or malleable backing plates when conduit is installed on the interior or exterior surface of any exterior building wall.

1.04 SUBMITTALS

- A. Submit Shop Drawings for equipment provided under this Section.
 - 1. All equipment this section, including:
 - a. Manufacturer's name
 - b. Model numbers
 - c. Materials of construction and load ratings (lbs)
 - 2. Schedule of hangers and support devices with support spacing.
 - 3. Details and calculations for sizing steel utilized for trapeze or special designed supports.
 - 4. Structural attachments, inserts and concrete anchors.

1.05 DESIGN CRITERIA

- A. Support materials shall be steel or stainless steel unless specifically indicated.
- B. Design, structural support members and support devices with safety factor of not less than 2.0.
- C. Hangers, support devices and hardware shall be steel and shall have factory standard primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application. Coat cut edges, welds or any damaged finish with galvanized paint.
- D. Where conduit can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
- E. Unless otherwise indicated, continuous insert channels are not allowed.
- F. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.

- G. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.
- H. Proposed weld attachments to building structure shall be reviewed by Structural Engineer.
 - 1. Execution of this work may be assigned to General Trades responsible for building structural steel.
 - 2. Cost for this work, however, will remain the responsibility of this Contractor.
- I. Fasteners including concrete anchors for seismic application shall meet ICBO Evaluation Report and requirements of local authorities.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Conduit Hangers and Supports.
 - 1. Erico
 - 2. Cooper B-Line
- B. Beam Clamps
 - 1. Erico
- C. Wall Anchors
 - 1. Hilti
 - 2. Rawl
- D. Metal Framing Support System (Strut System).
 - 1. Cooper B-Line
 - 2. Kindorf
 - 3. Unistrut

2.02 HANGER RODS

- A. Furnish rods complete with adjusting and lock nuts.
- B. Rods shall have electro-plated zinc or hot dip galvanized finish.
- C. Size rods for individual hangers and trapeze supports as required.

2.03 BEAM CLAMPS

- A. Bolt-On
- B. Hammer-On
- C. Malleable Iron
- D. Stamped Steel
- E. Support 1/4" and 3/8" threaded rod.

2.04 WALL ANCHORS

- A. Flush or shell type, meeting description in Federal specification FF-S-325, Group VIII, Type 1 for expansion shield anchors.
- B. Select anchors with minimum safety factor of 8.0.

2.05 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

- A. Channels shall have epoxy paint or electro-galvanized finish.
- B. Channels shall not be lighter than 12 ga.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Furnish and install all supports as required to fasten all electrical components required for the project, including free standing supports required for those items remotely mounted from the building structure, catwalks, walkways, etc.
- B. Fasten hanger rods, conduit clamps, outlet, junction and pull boxes to building structure using pre-cast insert system, preset inserts, beam clamps, expansion anchors, or spring steel clips (interior metal stud walls only).
- C. Select and size building attachments in accordance with manufacturer's instructions.
- D. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchors in concrete structures; sheet metal screws in sheet metal studs and wood screws in wood construction.
- E. Do not use powder-actuated anchor devices.
- F. Fabricate supports from galvanized structural steel or steel channel. Use hexagon head bolts with spring lock washers under all nuts.
- G. File and de-bur cut ends of support channel and spray paint with cold galvanized paint to prevent rusting.
- H. Coordinate hanger and support installation to avoid work of other trades.
- I. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- J. Do not fasten supports to piping, ductwork, mechanical equipment, cable tray or conduit.
- K. Do not drill structural steel members unless approved by Structural Engineer.
- L. Do not support equipment or conduit from metal roof decking.
- M. Conduit shall not be supported by other conduit.
- N. Install surface-mounted cabinets and panelboards with minimum of four anchors. Provide steel channel supports to stand cabinet one inch off wall.
- O. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud wall.
- P. Refer to Section 16010 - Basic Electrical Requirements, for requirements of personnel injury protection guards for supporting devices.
- Q. Supporting conduits from ceiling suspension wires is not permitted.

3.02 BEAM CLAMPS

- A. Provide locknut for hanging rod at clamp.
- B. C-clamps are allowed for rod size 1/2" or smaller.

3.03 TRAPEZE SUPPORTS

- A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.

3.04 CONDUIT MOUNTING PEDESTALS

- A. Use for all conduit on roof. Install bottom of pedestal flat on roof deck, insulate exterior of pedestal, flash and counter flash.

3.05 CONCRETE ANCHORS

- A. Anchor application, size, and placement shall be reviewed and approved by Structural Engineer prior to installation.

END OF SECTION 16190

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SECTION 16195 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16010 - Basic Electrical Requirements
- B. Section 16110 - Raceways
- C. Section 16120 – Wire and Cable

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

PART 2 - PRODUCTS

2.01 IDENTIFYING DEVICES

- A. Stencil Paint:
 - 1. Oil-based, alkyl enamel, black unless otherwise noted.
- B. Marker System:
 - 1. Acceptable Manufacturers: Brady USA, Ideal, Marking Services Inc. (MSI), Seton.
 - 2. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant 2 inches wide; compounded for outdoor use.
 - 3. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather-and chemical-resistant coating and matching wraparound adhesive tape for securing ends.
 - 4. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment.
 - 5. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies.
 - 6. Snap-Around, Color-Coding Bands: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies.
- C. Laminated Plastic Nameplates:
 - 1. ASTM D 709, Type I, cellulose, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore.
 - 2. Nameplates shall have 1/2" high lettering, except where space is limited letters may be 1/4" high.
 - 3. Face of nameplate to be black and letters to be white, except emergency power equipment nameplates are to have white face with red letters.
 - 4. Fasteners shall be small metal screws, pop rivets or contact-type with permanent adhesive.

PART 3 - EXECUTION

3.01 GENERAL

- A. After painting is completed, identify equipment as indicated. Locate identification as conspicuously as possible except where such would distract from finished area.

3.02 IDENTIFICATION

- A. Engraved plastic nameplates shall be securely attached to:
 - 1. Motor Starters.
 - 2. Each separately mounted circuit breaker or disconnect switch.
- B. 4" round, 4" square and 4-11/16" junction boxes concealed above ceilings may be identified with neat lettering on cover with permanent type black marking pen.
- C. Nameplates shall identify equipment or load controlled and/or function and shall be same as indicated on Contract Documents. Voltages shall be shown on panelboard nameplates.
- D. Motor starter nameplates shall include motor designation and horsepower.
- E. Group conductors as to circuits and arrange in neat manner in pull boxes, cabinets and panelboards. Group, bind together with nylon ties and identify conductors as to feeder or branch circuit. Phase identification shall be consistent throughout system.
- F. Identify each conductor of all systems at each panel, pull box and at each outlet with permanently attached, wrap around, adhesive markers.
- G. Identification of junction boxes and conductors shall include panelboard, switchboard or motor control center, circuit number, phase, control circuit number or other appropriate number or letter that will expedite future tracing and trouble shooting.
- H. Conduit and boxes shall be spot painted. The following colors shall be used:
 - 1. Orange 277/480V

END OF SECTION 16195

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SECTION 16440 - DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 RELATED WORK

- A. Section 16120 - Wire and Cable
- B. Section 16190 - Supporting Devices
- C. Section 16195 - Electrical Identification

1.02 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.03 DESCRIPTION

- A. This Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.04 REFERENCE STANDARDS

- A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.
- B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures.
- C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
- D. NFPA 70 - National Electrical Code.
- E. UL 98 - Enclosed and Dead Front Switches.
- F. UL 486A - 468B - Wire Connectors.
- G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
- H. UL 869A - Reference Standard for Service Equipment.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.
- B. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- C. Test Reports:
 - 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations of disconnect switches and ratings of installed fuses.

2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.06 QUALITY ASSURANCE

- A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with manufacturer's written instructions.

1.08 WARRANTY

- A. The manufacturer shall provide a standard one-year written warranty against defects in materials and workmanship for all products specified in this Section. The warranty period shall begin on the date of substantial completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Square D.
- B. General Electric.
- C. Cutler-Hammer.
- D. Siemens.

2.02 DISCONNECT SWITCHES

- A. NEMA KS 1, UL 98.
- B. Load interrupter enclosed knife switch, heavy-duty type.
- C. Fusible or non-fusible type as indicated.
- D. Switch Interiors:
 1. Switch blades that are visible in "OFF" position when switch door is open.
 2. Plated current carrying parts.
 3. Removable arc suppressors to permit easy access to line side lugs.
- E. Switch Mechanism:
 1. Quick-make, quick-break, with visible blades and externally operable handle.
 2. Lockable only in "OFF" position and accept three industrial type, heavy-duty padlocks.
 3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.

4. Defeater mechanism to bypass interlock.
5. Operating handle integral part of enclosure.
6. Handle to physically indicate "ON" and "OFF" position.

F. Ratings:

1. Ampacity as indicated on drawings.
2. Horsepower rated.

G. Fusible Switches:

1. Rejection clips for Class R fuses specified.
2. Provisions for Class J or Class L fuses, as applicable.

2.03 LUGS

- A. Front removable lugs.
- B. Labeled for 75°C copper and aluminum conductors.
- C. Multiple lugs to match number of conductors per phase.
- D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for No. 10 AWG or smaller conductors.

2.04 ACCESSORIES:

- A. Solid neutral assembly, where required.
- B. Equipment ground kit.
- C. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by variable frequency drive (VFD).

2.05 ENCLOSURES

- A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
- B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
- C. Code-gauge galvanized steel.
- D. Manufacturer's standard gray enamel finish over prime coat.
- E. Surface-mounted.

PART 3 - EXECUTION

3.01 COORDINATION WITH MANUFACTURER

- A. Instruct manufacturer about the location of incoming lugs, i.e. top or bottom feed based on incoming feeder entrance location.
- B. Verify that "touch-up" paint kit is available for repainting.

3.02 EXAMINATION

- A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

- B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.03 INSTALLATION

- A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.
- B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer's written instruction.
- C. Do not support disconnect switches and/or enclosed circuit breakers only by raceway.
- D. Install top disconnect switch and/or enclosed circuit breaker handle a maximum of 6'-6" above finished floor.
- E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A - 486B.
- F. Install engraved plastic nameplates under provisions of Section 16195. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
 - 1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.
- G. Install fuses in fusible switches at job site per mechanical equipment requirements.

3.04 CONNECTIONS

- A. Connect wiring according to Section 16120 - Wire and Cable.

3.05 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
- B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

3.06 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.07 ADJUSTING

- A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings, as indicated on drawings.

3.08 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION 16440