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SECTION 15010 - BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including The General Conditions of the Contract for Construction, General and Supplementary Conditions and Division-1 Conditions specification sections apply to the Division 15 specifications and drawings.
- B. Related Sections: Refer to all sections in Division 15. Refer to Division 16 specification section and Division 16 drawings.

1.2 SUMMARY:

- A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 15. It expands and supplements the requirements specified in Division 1.

1.3 PROJECT CONDITIONS:

- A. The Contractor shall be required to attend a mandatory pre-bid walk-thru and shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for these existing conditions.
- B. Field verify all existing conditions prior to submitting bids.
- C. Report any existing damaged equipment or systems to the Owner prior to any work.
- D. Protect all mechanical and electrical work against theft, injury or damage from all causes until it has been tested and accepted.
- E. Be responsible for all damage to the property of the Owner or to the work of other contractors during the construction and guarantee period. Repair or replace any part of the work which may show defect during one year from the final acceptance of all work. Provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner's carelessness or improper use.

1.4 ACCESSIBILITY:

- A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.
- B. Extend all grease fittings to an accessible location.
- C. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, fans, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification and Division 15 for duct access door requirements.
- D. The minimum size of any access door shall not be less than the size of the equipment to be removed or 12 inches x 12 inches if used for service only.

- E. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.
 - F. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, approved shop fabricated access doors with DuroDyne hinges may be used.
 - G. Access doors in fire-rated walls and ceilings shall have equivalent U.L. label and fire rating.
- 1.5 ROUGH-IN:
- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
 - B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.
- 1.6 REQUIREMENTS OF REGULATORY AGENCIES:
- A. Refer to Division 1.
 - B. Execute and inspect all work in accordance with all Underwriters, local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.
 - C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.
 - D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state and local regulations.
 - E. The handling, removal and disposal of lead based paint and other lead containing materials shall comply with EPA, OSHA, and any other Federal, State, or local regulations.
 - F. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
- 1.7 REQUIREMENTS OF LOCAL UTILITY COMPANIES:
- A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required for the project.
- 1.8 PERMITS AND FEES:
- A. Refer to Division 1.
 - B. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.

1.9 MECHANICAL INSTALLATIONS:

- A. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
- B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both.
- C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, take the necessary measurements and prepare the drawings.
- D. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as contemplated without interferences between systems, with structural elements or with the work of other trades.
- E. Coordinate the installation of mechanical materials and equipment above and below ceilings with suspension system, light fixtures, and other building components.
 - 1. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of priority.
 - a. Plumbing waste, vent piping and roof drain mains and leaders.
 - b. Supply, return and exhaust ductwork.
 - c. Fire sprinkler mains and leaders.
 - d. Electrical conduit.
 - e. Domestic hot and cold water, medical gas piping.
 - f. Fire sprinkler branch piping and sprinkler runouts.
- F. Verify all dimensions by field measurements.
- G. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- H. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.
- I. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
- J. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.
- K. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
- L. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

- M. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
- 1.10 BELTS, SHEEVES, IMPELLERS:
- A. The Mechanical Contractor shall coordinate with the Test and Balance Contractor and supply correctly-sized drive belts, sheeves, and trimmed impellers.
- 1.11 EXCAVATING AND BACKFILLING:
- A. General:
 - 1. Provide all necessary excavation and backfill for installation of mechanical work in accordance with Division 2.
 - 2. In general, follow all regulations of OSHA as specified in Part 1926, Subpart P, "Excavations, Trenching and Shoring." Follow specifications of Division 15 as they refer specifically to the mechanical work.
 - B. Contact Owners of all underground utilities to have them located and marked, at least 2 business days before excavation is to begin. Also, prior to starting excavation brief employees on marking and color codes and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.
 - C. Provide all necessary pumping, cribbing and shoring.
 - D. Walls of all trenches shall be a minimum of 6 inches clearance from the side of the nearest mechanical work. Install pipes with a minimum of 6 inches clearance between them when located in same trench.
 - E. Pipe Trenching:
 - 1. Dig trenches to depth, width, configuration, and grade appropriate to the piping being installed. Dig trenches to 6 inches below the level of the bottom of the pipe to be installed. Install 6 inches bed of pea gravel or squeegee, mechanically tamp to provide a firm bed for piping, true to line and grade without irregularity. Provide depressions only at hubs, couplings, flanges, or other normal pipe protrusions.
 - F. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be reviewed by the soils engineer. In no case shall lumber, metal or other debris be buried in with backfill.
 - 1. Provide warning tape for marking and locating underground utilities. Tape shall be specifically manufactured for this purpose and shall be polyethylene film, 6 inches wide, 0.004 inches thick and have a minimum strength of 1750' psi. Tape shall carry continuous inscription naming the specific utility.
 - a. Tape shall have magnetic strip and be used for exterior underground system only.
 - G. Trench Backfill:
 - 1. Backfill to 12 inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly.

2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6 inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.
 - H. After backfilling and compacting, any settling shall be refilled, tamped, and refinished at this contractor's expense.
 - I. This contractor shall repair and pay for any damage to finished surfaces.
 - J. Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6 inch lifts and mechanically tamping to achieve 95 percent compaction.
 - K. Use suitable excavated material to complete the backfill, installed in 6 inch lifts and mechanically compacted to seal against water infiltration. Compact to 95 percent for the upper 30 inches below paving and slabs and 90 percent elsewhere.
- 1.12 CUTTING AND PATCHING:
- A. This Article specifies the cutting and patching of mechanical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment.
 - B. Refer to Division 1.
 - C. Do not endanger or damage installed work through procedures and processes of cutting and patching.
 - D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.
 - E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.
 - F. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 1. Uncover work to provide for installation of ill-timed work;
 2. Remove and replace defective work;
 3. Remove and replace work not conforming to requirements of the Contract Documents;
 4. Remove samples of installed work as specified for testing;
 5. Install equipment and materials in existing structures;
 6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineer observation of concealed work.
 - G. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new work.
 - H. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 - I. Provide and maintain an approved type of temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas. Temporary partitions must not impede access to building egress.

- J. Locate identify, and protect mechanical and electrical services passing through remodeling or demolition area and serving other areas required to be maintained operational. When services must be interrupted, provide temporary services for the affected areas and notify the Owner prior to changeover.

1.13 TEMPORARY FACILITIES:

A. Light, Heat, Power, Etc.:

- 1. Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.

B. Use of Permanent Building Equipment for Temporary Heating or Cooling:

- 1. Permanent building equipment shall not be used without written permission from the Owner. If this equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer's instructions and protected with filters, strainers, controls, reliefs, etc. Steam and hydronic systems shall be flushed and chemically treated. All filters required for the construction period shall be equivalent to the filters required for the final installation. All filters shall be replaced at the time of substantial completion. The guarantee period of all equipment used shall not start until the equipment is turned over to the Owner for his use.

C. Refer to AIA Document A 201-1987, paragraph 9.6.6, 9.9 and 11.3.11.

1.14 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. Refer to the Instructions to Bidders and Division 1. "PRODUCTS, OPTIONS AND SUBSTITUTION".

- B. Materials and equipment of equivalent quality may be substituted for those scheduled or identified by name on the drawings if so reviewed by the Architect/Engineer prior to bidding. This may be done by submitting to the Architect/Engineer at least seven (7) working days prior to the bid date a letter in triplicate requesting prior review. This submittal shall include all data necessary for complete evaluation of the product.

1.15 MECHANICAL SUBMITTALS:

A. Refer to the Conditions of the Contract (General and Supplementary), Division 1.

- 1. All mechanical submittals shall be submitted by specification section submitted at one time. "Piece-Meal" or "Partial" submittals will be returned, unless prior approval from the Engineer has been obtained.[Exception-multiple bid pack process].
- 2. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.
- 3. At least one copy of the first submittal package shall be provided in expandable, 3 post, hard back binders, sized to fit all future submittals for this job. The cover shall be identified with the job name, Owner's project number, date, prime contractor's name, etc.
- 4. Each submittal shall be tabbed by the mechanical specification section it is specified in.
- 5. An index shall be provided which includes:

- a. Product
 - b. Plan Code (if applicable)
 - c. Specification Section
 - d. Manufacturer and Model Number
6. Fire protection and coordination drawings do not apply to the above. These drawings may be submitted in a separate submittal.
- B. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.
- C. All equipment shall conform to the State and/or local Energy Conservation Standards.
- D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by and stamped by the Contractor. Data submitted from subcontractors and material suppliers directly to the Engineer will not be processed unless prior written approval is obtained by the Contractor.
- E. Before starting work, prepare and submit to the Architect/Engineer six (6) sets of all shop drawings and descriptive equipment data required for the project. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned "Revise and Resubmit". Where an entire submittal package is returned for action by the Contractor, the Engineer will mark up two sets, keep one, and return the rest. Continue to submit six (6) sets of any individual shop drawings, product data or samples which were returned without a "make corrections noted" or "no exceptions taken" action, until they are so marked. When a "Make Corrections Noted" is received, make the required corrections for inclusion in the operation and maintenance manual. Submittals marked "Make Corrections Noted" shall not be resubmitted during the submittal process.
- F. The Design Professionals review and appropriate action on submittals, such as shop drawings, product data, samples and other data, as required by the Design Professional, is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include review of the accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes, construction means or methods, coordination of the work with other trades or construction safety precautions, all of which are the sole responsibility of the Contractor. The Design Professional's review shall be conducted with reasonable promptness while allowing sufficient time in the Design Professional's judgment to permit adequate review. Review of a specific item shall not indicate that the Design Professional has reviewed the entire assembly of which the item is a component. The Design Professional shall not be responsible for any deviations from the contract documents not brought to the attention of the Design Professional in writing by the Contractor. The Design Professional shall not be required to review partial submissions or those for which submissions of correlated items have not been received.
- 1.16 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS:
- A. Product Data:
1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.
 2. Delete or mark-out portions of pre-printed data which are not applicable.

3. Where operating ranges are shown, mark data to show portion of range required for project application.
 4. For each product, include the following:
 - a. Sizes.
 - b. Weights.
 - c. Speeds.
 - d. Capacities.
 - e. Piping and electrical connection sizes and locations.
 - f. Statements of compliance with the required standards and regulations.
 - g. Performance data.
 - h. Manufacturer's specifications.
- B. Shop Drawings:
1. Shop Drawings are defined as mechanical system layout drawings prepared specifically for this project, or fabrication and assembly type drawings of system components to show more detail than typical pre-printed materials.
 2. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale, min 1/8"-1'-0", unless otherwise noted.
 - a. Show clearance dimensions at critical locations.
 - b. Show dimensions of spaces required for operation and maintenance.
 - c. Show interfaces with other work, including structural support.
- C. Test Reports:
1. Submit test reports which have been signed and dated by the firm performing the test.
 2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.
- D. Required submittals:
1. Provide submittals for each item of equipment specified or scheduled in the contract documents. See table at the end of this section.
- E. If more than two submittals (either for product data, shop drawings, record drawings, or test and balance reports) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.
- 1.17 MECHANICAL COORDINATION DRAWINGS:
- A. Prepare and submit a set of coordination drawings as necessary or required by the Engineer showing major elements, components, and systems of mechanical equipment and materials in relationship with other building components. Prepare drawings to an accurate scale of 1/4"-1'-0" or larger. Indicate the locations of all equipment and materials, including pipe and duct elevations, clearances for installing and maintaining insulation, servicing and maintaining equipment, valve stem movement, and similar requirements. Indicate movement and positioning of large equipment into the building during construction.
 - B. Prepare floor plans, reflected ceiling plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Show work of all trades involved in locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the work, including (but not necessarily limited to) ductwork, pneumatic tube system, piping, fire protection, electrical conduit, switchgear. Provide coordination drawings for the following:

1. Mechanical equipment room layouts;
2. Specific equipment installations, including:
 - a. Chillers;
 - b. Tanks and heat exchangers;
 - c. Air handling units;
 - d. Pumps
3. Work in pipe spaces, chases, trenches, and tunnels;
 - a. Exterior wall penetrations;
 - b. Ceiling plenums which contain piping, ductwork pneumatic tube systems, or equipment in congested arrangement;
 - c. Installations in mechanical riser shafts, at typical sections and crucial offsets and junctures;
 - d. Exterior underground lines in common excavation;
 - e. Roof plan showing equipment intakes, exhausts and plumbing vents.

1.18 PRODUCT LISTING:

- A. Prepare listing of major mechanical equipment and materials for the project, within (2) two weeks of signing the Contract Documents and transmit to the Architect. A sample schedule is included at the end of this section to complete this requirement.
- B. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
 1. Provide all information requested.
 2. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION."
- C. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
 1. Provide products which are compatible within systems and other connected items.

1.19 SCHEDULE OF VALUES:

- A. Within 30 days of award of this contract, submit a schedule of values, based on the contract amount for the following categories:
 1. Site Utilities;
 2. Plumbing;
 3. Fire Protection;
 4. HVAC:
 - a. Equipment,
 - b. Sheet Metal,
 - c. Piping,
 - d. Insulation,
 - e. Test and Balancing,
 - f. Specialty Systems,
 - g. Temperature Controls.

5. Demolition;

a. Miscellaneous.

1.20 NAMEPLATE DATA:

- A. Provide permanent operational data nameplate on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.21 DELIVERY, STORAGE, AND HANDLING:

- A. Refer to Division 1.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage or contamination during shipment, storage, and handling.
- C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust and moisture.
- D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.
- E. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- F. Protect stored pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.
- G. Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or be packaging with durable, waterproof wrapping.

1.22 RECORD DOCUMENTS:

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.
- B. Keep a complete set of record document prints in custody during entire period of construction at the construction site. Documents shall be updated on a weekly basis.
- C. Mark Drawing Prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1foot-0inches from where shown on the drawings.

- D. At the completion of the project, obtain from the Architect a complete set of the Mechanical Construction Documents in the electronic format used by the design team. This set will include all revisions officially issued through the Architect. The Contractor shall transfer all revisions noted on the record document prints to the electronic drawings. The Contractor shall transmit the final record documents in the electronic format used on the project to the Architect. This contract will not be considered completed until these record drawings have been received and reviewed by the Architect/Engineer.

1.23 OPERATION AND MAINTENANCE DATA:

- A. Refer to Division 1.

OR

No later than [] four (4) weeks prior to the completion of the project, make up [] minimum of four sets of operating and maintenance manuals, as specified in Sections of Division 1.

- B. The testing and balancing report shall be submitted and received by the Engineer at least fifteen calendar days prior to the contractor's request for final observation time frame requirements. Include in the O & M Manual after review with "No Exceptions Taken" has been accomplished.
- C. In addition to the information required above / by Division 1 for Maintenance Data, include the following information:
1. Description of mechanical equipment, function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions.
 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 4. Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.
 5. Manufacturer's service manuals for all mechanical equipment provide under this contract.
 6. Include the valve tag list.
 7. Name, Address and Telephone number of party to be contacted for 24-hour service for each item of equipment.
 8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.
 9. Complete parts list.
 10. Mechanical warranties.
- D. This contract will not be considered completed nor will final payment be made until all specified material, including testing and balancing report, is received in this operating and maintenance report and the manual is reviewed by the Architect/Engineer.

1.24 LUBRICATION OF EQUIPMENT:

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

- B. Contractor shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.
- C. Furnish the Engineer with a typewritten list included in the O and M manuals of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.25 DEMOLITION:

- A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.
- B. During the demolition phase of this contract it is the responsibility of this Contractor to carefully remove existing equipment, piping or ductwork and related items either as shown on the demolition drawings as being removed, or as required for the work. These items shall be tagged, protected from damage, and stored as directed by the Architect. A list of all items stored shall be turned over to the Architect. At the completion of the remodeling work or when directed by the Architect, all stored items not reused or wanted by the Owner shall be removed from the premises. Disposition of items not reused is by the direction of the Architect/Engineer.
 - 1. Return existing thermostats to the owner.
 - 2. Return all demolished control valves and devices to the Owner.
 - 3. Return existing plumbing fixtures to the Owner.
- C. The location of existing equipment, pipes, ductwork, etc., shown on the drawings has been taken from existing drawings and is, therefore, only as accurate as that information. All existing conditions shall be verified from field measurements with necessary adjustment being made to the drawing information.
- D. If asbestos material, in any form, is discovered by this contractor in the process of his work, he shall report such occurrence to the Architect/Owner immediately. The Architect/Owner will determine the action to be taken for the asbestos removal, which is not a part of the work to be done under this Division.

1.26 WARRANTIES:

- A. Refer to the Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case the entire mechanical system shall be warranted no less than one year from the time of acceptance by the Owner.
- B. Compile and assemble the warranties specified in Division 15, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference / the operating and maintenance manuals.
- C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.27 CLEANING:

- A. Refer to Division 1.

- B. Refer to Division 15, "TESTING, ADJUSTING AND BALANCING" for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.

1.28 PROJECT CLOSEOUT:

- A. In addition to the requirements specified in Division 1, complete the requirements listed below.
- B. The Contractor shall be responsible for the following Mechanical Checklist either by performing and/or coordinating such items prior to applying for certification of substantial completion.
 - 1. Refer to individual specification sections for additional requirements.
- C. Mechanical Checklist

EDIT NOTE: Edit matrix carefully and include X's in boxes where needed especially closeout items.

SPEC SECTION	ITEM	REQUIREMENTS										
		SUBMITTALS			SUPPLEMENTAL		FACTORY REP SUPER-VISION AT SITE	**TRAINING REQ=D AT SITE	**EXTRA MATERIAL	At completion of project obtain owners sign off that has received the following:		
		Shop drawings	Product Data	Include in O & M	TEST	REPORT				Training of Product	Extra Materials	Document
15010	EQUIPMENT WARRANTIES			X								
15010	O&M MANUALS											
15010	COORDINATION DRAWINGS	X										
15010	RECORD DRAWINGS	X	X	X								
15040	MOTORS, STARTERS AND DRIVES	X	X	X	X ⁴	X	X ⁵					
15040	VARIABLE SPEED DRIVES	X	X	X	X	X	X	X	X			
15050	MECHANICAL FIRE STOPPING		X	X				X				
15055	PIPE		X	X	X	X						
15055	PIPE FLUSH/CLEAN			X	X	X						
15055	PIPE DISINFECTION (POTABLE H ₂ O)		X	X	X	X						
15100	VALVES		X	X								
15120	PIPING SPECIALTIES		X	X								
15125	PIPE EXPANSION JOINTS		X	X								
15135	METERS AND GAUGES		X	X		X ⁶			X			

SPEC SECTION	ITEM	REQUIREMENTS											
		SUBMITTALS			SUPPLEMENTAL		FACTORY REP SUPER-VISION AT SITE	**TRAINING REQ=D AT SITE	**EXTRA MATERIAL	At completion of project obtain owners sign off that has received the following:			
		Shop drawings	Product Data	Include in O & M	TEST	REPORT				Training of Product	Extra Materials	Document	
15140	SUPPORTS AND ANCHORS	X	X	X									
15190	MECHANICAL IDENTIFICATION		X	X				X					
15241	VIBRATION CONTROL	X	X	X	X	X							
15250	MECHANICAL INSULATION		X	X									
15300	FIRE PROTECTION	X	X	X	X	X		X	X				
15411	WATER DISTRIBUTION PIPING		X	X	X	X			X				
15420	DRAINAGE & VENT SYSTEMS		X	X	X	X							
15440	PLUMBING FIXTURES		X	X					X				
15453	PLUMBING PUMPS		X	X									
15456	WATER TREATMENT	X	X	X	X	X		X	X				
15456	TREATMENT			X				X					
15456	TREATMENT CHEMICALS			X					X				
15456	SYSTEM CLEANING ¹			X	X	X							
15456	BOILER CLEANING			X		X							
15458	WATER HEATERS		X	X				X					
15488	NATURAL GAS SYSTEMS		X	X	X	X			X				
15517	GLYCOL SYSTEMS		X	X	X	X		X	X				
15535	REFRIGERATION SPECIALTIES		X	X									
15540	HVAC PUMPS		X	X									
15556	BOILERS		X	X		X	X	X					
15570	BOILER ACCESSORIES		X	X									
15575	BREECHINGS, CHIMNEYS & STACKS	X	X	X									
15686	CENTRIFUGAL CHILLERS - AIR COOLED		X	X	X	X	X	X					
15743	AIR COOLED CONDENSERS		X	X		X ¹	X	X					

SPEC SECTION	ITEM	REQUIREMENTS										
		SUBMITTALS			SUPPLEMENTAL		FACTORY REP SUPER-VISION AT SITE	**TRAINING REQ=D AT SITE	**EXTRA MATERIAL	At completion of project obtain owners sign off that has received the following:		
		Shop drawings	Product Data	Include in O & M	TEST	REPORT				Training of Product	Extra Materials	Document
15755	HEAT EXCHANGERS		X	X					X			
15830	TERMINAL UNITS		X	X								
15831	ELECTRIC HEATING CABLES		X	X								
15851	AIR HANDLING FANS		X	X				X	X			
15855	AIR HANDLING UNITS	X	X	X				X	X			
15885	AIR CLEANING	X	X	X					X			
15891	METAL DUCTWORK	X	X	X	X	X						
15910	DUCTWORK ACCESSORIES		X	X		X			X			
15920	SOUND ATTENUATORS		X	X	X							
15932	AIR OUTLETS & INLETS		X	X					X			
15933	AIR TERMINALS		X	X								
15971	DIRECT DIGITAL CONTROL SYSTEMS	X	X	X		X	X	X				
15975	SEQUENCE OF OPERATION			X								
15990	TESTING ,ADJUSTING AND BALANCING			X		X						

¹ Warranty - 5 year

² Warranty Report/Warranty

⁴ See Specific Specification Section for Test & Certification Requirements

⁵ For Soft Starters

⁶ Requires Review & Approval from T & B Contractor

**Requires Owner Sign Off

END OF SECTION 15010

SECTION 15040 - MECHANICAL/ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. This section specifies the basic requirements for electrical components which are either separate components or are an integral part of all mechanical equipment. These components include, but are not limited to factory installed motors, starters, variable frequency drives and disconnect switches furnished as an integral part of packaged mechanical equipment.
- B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.
- C. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by Contractor.
- D. Refer to Table in Division 1 / 16 for Mechanical/Electrical coordination.
- E. See other sections of Division 15 for vibration and seismic control requirements.

1.2 QUALITY ASSURANCE:

- A. Manufacturers: Firms regularly engaged in manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Single Manufacturer: Provide all motors and starters for the project by a single manufacturer except when part of factory packaged equipment. All variable frequency drives and soft start starters for the project shall be by a single manufacturer, including packaged equipment except chillers.
- C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motors, motor starters, capacitors and drives similar to that required for this project.
- D. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors and drives.
- E. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces".
- F. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.
- G. UL Compliance: Provide equipment and components which are UL-listed and labeled.
- H. ETL Compliance: Provide equipment and components which are ETL-listed and labeled.
- I. IEEE Compliance: Comply with applicable requirements of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters and Std 519.

- J. NEMA Compliance: Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies", and Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)", pertaining to motor controllers/starters and enclosures.
 - K. Standards:
 - 1. NEMA Standards MG 1: Motors and Generators.
 - 2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
 - 3. NEMA Standard 250: Enclosures for Electrical Equipment.
 - 4. NEMA Standard KS 1: Enclosed Switches.
 - 5. Comply with National Electrical Code (NFPA 70).
 - L. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 16 sections. Comply with applicable requirements of Division 16 sections for electrical work of this section which are not otherwise specified.
- 1.3 SUBMITTALS:
- A. Product Data: Submit in accordance with Section 15010.
 - B. Shop Drawings: Submit dimensional drawings of VFD's and soft start starters showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general arrangements with incoming and outgoing conduit locations, schematic; connection diagram sufficient to install system, and enclosure details.
 - C. Wiring Diagrams: Submit schematic power and control wiring diagrams, prepared for this project, of complete VFD and soft start starter assemblies. General wiring diagrams with various non-applicable options shown are not acceptable. Clearly differentiate between factory and field wiring.
 - D. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.
 - 1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.
 - E. Electrical coordination listing. Provide the following information for each field wired electrical power connection. Information shall use nameplate data and nomenclature of actual installed nameplates. Information should list as a minimum:
 - 1. Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase.
 - 2. Number and location of field connections.
 - 3. Field interconnection wiring.
 - 4. Operating voltage and phase.
 - 5. Maximum fuse size or maximum overcurrent protection size (as applies).
 - 6. Minimum circuit ampacity.
 - 7. Full load amperes.
 - 8. Locked rotor current and duration for high inertia equipment.
 - 9. Manufacturers recommended overload setting (if applicable).

The contractor shall fully coordinate these items with all subcontractors prior to submittal.

1.4 PRODUCT STORAGE:

- A. All variable frequency drives shall be protected from dirt, debris, and moisture at all times. Variable frequency drives shall be wrapped air and water tight with dust-tight and moisture proof material until factory start-up of variable frequency drives is initiated.

Exception: Drives may be opened only during wiring terminations by temperature control contractor and/or electrical contractors.

- B. All motors not designed for exposure to water or moisture shall be protected at all times.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:

1. Motors

- a. Century/MagneTek
- b. Baldor
- c. Reliance
- d. Westinghouse
- e. Siemens-Allis
- f. General Electric
- g. Louis Allis
- h. Lincoln
- i. U.S. Motors
- j. Square D

2. Starters

- a. Cutler Hammer
- b. Allen-Bradley
- c. Sprecher & Schuh
- d. Square D
- e. Eaton
- f. Siemens

3. Soft Start Starters

- a. Allen-Bradley
- b. U.S. Electric
- c. Sprecher & Schuh
- d. Square D
- e. Siemens

4. Variable Frequency Drives

- a. Robicon
- b. ABB
- c. Reliance

- d. Allen-Bradley
- e. Square D
- f. Toshiba
- g. Grahm
- h. Eaton
- i. Cutler Hammer
- j. Siemens

2.2 MOTORS:

- A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.
1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.
 2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
 3. 2-speed motors shall have (1) single winding on poly- phase motors.
 4. Temperature Rating: Rated for 40 degrees C environment with maximum 80 degrees C temperature rise for continuous duty at full load (Class B Insulation). Provide Class F insulation for variable frequency drive motors.
 5. Starting capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
 6. Service Factor: 1.15 for poly-phase motors, ~~and~~ 1.35 for single phase motors, and 1.0 for inverter duty motors.
 7. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque. Design "E" shall not be used.
 - a. Frames: NEMA Standard No. 48 or 54; Use driven equipment manufacturer's standards to suit specific application.
 - b. Bearings:
 - 1) Ball bearings with inner and outer shaft seals.
 - 2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
 - 3) Bearings shall be rated for minimum L-10 life of 40,000 hours.
 - 4) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
 - 5) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
 - c. Enclosure Type:

- 1) Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
 - 2) Guarded drip-proof motors where exposed to contact by employees or building occupants.
 - 3) Weather protected Type I for housed outdoor use, TEPC II where not housed.
- d. Overload protection: Built-in thermal overload protection for all single phase motors and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
- e. Noise rating: "Quiet".
- f. Efficiency: All motors shall have a minimum efficiency as scheduled in Table 1 accordance with IEEE Standard 112, test method B and NEMA Chart 12-10. If efficiency not specified, motors shall have an efficiency equal to or greater than the "minimum efficiency standard", in accordance with IEEE Standard 112, test method B and NEMA Chart 12-10.
- g. Efficiency: All motors shall be NEMA premium efficiency motors, in accordance with NEMA standard MG-1, 2003, tables 12-12 and 12-13 or as listed below:

Motor Horse-power	Nominal Full-Load Efficiency					
	Open Motors, ODP			Enclosed Motors, TEFC		
	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
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
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
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0

*Efficiency and power factors may vary from above values, including but not limited to, multi-speed, explosion proof motors and/or special hermetic motors packaged with equipment. For these special applications motors shall be high-efficiency type and are subject to review by the engineer.

- h. Nameplate: indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
- 8. Phases and Current Characteristics: Unless indicated otherwise, provide squirrel-cage induction polyphase motors for 3/4 hp and larger, and provide capacitor-start single-phase motors for 1/2 hp and smaller, except 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type. Tri-voltage motors are not acceptable. Coordinate current characteristics with power specified in Division 16 sections. Do not purchase motors until power characteristics available at building site have been confirmed by contractor.
- 9. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate any motors which differ from the scheduled horsepower sizes or correct any motor which does not meet the listed efficiency as called for in mechanical or electrical plans and specifications.
- 10. Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit. These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.
- 11. All equipment specified to operate with variable frequency drives shall be provided with inverter-duty motors specifically designed for variable speed operation with high efficiency at part load conditions and constructed with Class F inverter grade insulation. Inverter duty motors shall meet requirements of NEMA MG-1 part 31.4 O.4.2.
- 12. All motors which will be operated by a variable frequency drive shall be warranted against any damage or defects as a result of being used with a variable frequency drive.

2.3 STARTERS, ELECTRICAL DEVICES AND WIRING:

A. Motor Starter Characteristics:

- 1. Coordinate with the Electrical Contractor for motor control center starters provided by Division 16.
- 2. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
- 3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
- 4. Provide two-speed starters with a High-Low selector switch wired to allow manual speed selection with the H-O-A in HAND or remote speed selection in AUTO. Provide an automatic accelerating relay/timer to assure that the motor will always start at low speed and operate at an adjustable time before switching to high speed. Also, provide an integral automatic decelerating timing relay to prevent damage to the motor and load when switching from high to low speed. High and low speed contactors shall be mechanically and electrically interlocked. Complete instructions shall be provided for

adjusting the timer in the field to match the deceleration characteristics of the driven equipment.

5. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA style, sized and rated, 75 degrees C.

B. Manual switches shall have:

1. Pilot lights and extra positions for multi-speed motors.
2. Overload protection: melting alloy type thermal overload relays.

C. Magnetic Starters:

1. Unless otherwise indicated, provide NEMA style, sized and rated magnetic starters including contacts and coils for motors 3/4 hp and larger and for smaller motors where interlock or automatic operation is indicated or required:
 - a. Maintained contact H-O-A push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
 - b. Solid state adjustable motor overload. Select range so that upper limit is no more than 150 percent of the connected motor full load amps.
 - c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections.
In addition to the interlock & switches specified above each starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.
 - d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
 - e. Under-voltage release or protection. Re-start of equipment shall be automatic, except for the following:
 - 1)
 - 2)
 - 3)
 - f. All 3-phase motors 2 hp and larger shall be protected against loss of phase (single phasing protection) wired into the starter. Reset shall be manual.
 - g. Where reduced voltage starting is required, the starting method shall be part winding or closed transition auto-transformer/solid state electronic starting. Motors shall be constructed accordingly. Other methods of reduced voltage starting shall not be used unless reviewed by the Engineer prior to bid.
 - h. All starters used for life safety systems shall have an additional control relay to by-pass all external safeties and internal safeties except for overload protection. Coordinate with 15975.

D. Motor connections:

1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

2.4 SOFT-START STARTERS:

A. Provide soft-start starters for the following equipment:

- 1.
- 2.
- 3.
- 4.

B. Soft start starters shall be provided for the specified service. Soft start starters shall consist of a main disconnect switch, a mechanical contactor, a six-SCR full wave bridge solid state reduced voltage starter, a thermal overload relay factory assembled in a single enclosure, with ratings, features and accessories as specified below. The soft start shall be capable of controlling the starting inrush of a NEMA design B motor, and to reduce water hammer effects of the pumps when the motor is stopped.

C. Ratings and features:

1. Starter voltage as noted on electrical drawings.
2. Enclosure type, NEMA 1 ventilated.
3. Main AC line fused disconnect or circuit breaker mounted and wired, with a door interlock mechanism and padlocking means.
4. Starter shall include a full NEMA style, HP sized and rated series contactor, including contacts and coils, ahead of the solid state electronics. Contactor shall open on normal stop command, and if a shorted SCR is detected.
5. Starter shall be rated for a minimum of 350 percent current for 30 seconds.
6. Starter shall include adjustable thermal overload protection.
7. Starter shall include maintained contact H-O-A selector switch and red running pilot light.
8. Starter shall include an integral 120V control circuit transformer with primary and secondary fusing.
9. Starter shall be rated for full current operation at 40 degrees C ambient temperature.
10. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections.
In addition to the interlock & switches specified above each soft start starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.

D. Protective features and adjustments:

1. SCR's shall be rated 1600 PIV minimum.
2. Instantaneous overcurrent trip shall be included if current exceeds 900 percent FLA.
3. Metal Oxide Varistor (MOV) suppressors shall be provided.
4. Heat sink overtemperature switch shall be provided.
5. Starter shall include shorted SCR detection and lockout.
6. Starter shall not start if a phase loss condition is present.
7. Diagnostics shall include LED indicators for:
 - a. 3 phase power present
 - b. Shorted SCR detected
 - c. Motor overload
 - d. Instantaneous overcurrent
 - e. Starter ready
 - f. Starter on
 - g. Power supply failure

8. A fault relay shall be included to trip the series contactor in the event of motor thermal overload, instantaneous overcurrent, of presence of a shorted SCR.
9. Adjustments shall include ramp time, current limit, jog voltage, jog time, and deceleration time.

E. Operational Features:

1. On starting, the starter shall be capable of applying an adjustable "jog" voltage to the motor for an adjustable time to magnetize the motor, then automatically switch to a controlled current ramp mode to accelerate the load.
2. On stopping, the starter shall include an "anti-water hammer" circuit which is capable of accepting a 0-10V DC signal proportional to flow from the building automation system and controlling the voltage to the motor to obtain a smooth reduction in flow without excessive pipe movement or water hammer. As a backup, a linear voltage ramp deceleration mode shall be available.
3. Field Start-up and Service: Soft starter supplier shall provide authorized factory trained service personnel to do on-site start-up and adjustment for each soft start starter.

2.5 DISCONNECT SWITCHES:

- A. See Division 16 for requirements.

2.6 DRIVES:

A. V-Belt Drives:

1. Capacity of V-Belt Drives at rated RPM shall be not less than 150 percent of motor nameplate horsepower rating.
2. V-Belt Drive combinations shall be limited to A, B, C and fractional horsepower belts. 3V, 5V and 8V belts and sheaves shall not be used.
3. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
4. All fixed pitch sheaves, including single groove fan sheaves, shall be of the bushed type. Fixed bore sheaves will not be acceptable for adjustable pitch sheaves.
5. Belts: Oil-resistant, nonsparking, and nonstatic.
6. Unit manufacturer shall provide OSHA approved belt guard with tachometer holes.
7. For equipment serving hazardous or critical systems (i.e., fume hoods, bio-hazards, life safety, etc.), all fans shall be provided with 1.5 times the number of belts normally required to meet above requirements, with a minimum of 2 belts.

2.7 VARIABLE FREQUENCY DRIVES:

A. General:

1. Comply with NEMA (including NEMA ICS 7.1), and IEEE (including IEEE 519-1992) Standards as applicable to wiring methods, construction and installation and operation of VFDs. Comply with applicable requirements of UL 908. "Power Conversion Equipment" and UL 508 C. Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing. The entire unit shall carry this label, not just components.

2. Provide the following factory tests on VFD assembly as a complete package (not just individual components):
 - a. High pot test per UL 508.
 - b. Test assembled panel with a motor load.
 - c. Test operation of all components and pilot lights.
 3. The manufacturer shall verify compatibility of each VFD unit with the motor being supplied under Division 15. The vendor shall be responsible for reviewing Division 15 specifications sections, plans and schedules related to motors prior to bid and shall notify the Engineer at least ten (10) days prior to the bid of any discrepancies or incompatibilities between VFD units and motor characteristics.
- B. Enclosure:
1. Mount VFD and all components within a NEMA 1 metal enclosure. By-pass components shall be in a separate compartment or enclosure as noted below.
 2. Provide floor stand where building walls are not suitable for mounting drive.
 3. Provide filtered, fan powered ventilation for drive cooling. Fan shall be sized for "dirty filter" condition, at project altitude.
 4. Drive and by-pass enclosure doors shall have provisions for locking with a padlock or integral lock, keyed to the building standards.
 5. Switches and pilot lights shall be labeled with engraved plastic laminate tags riveted or similarly permanently fastened.
- C. By-pass and Disconnects:
1. Provide manual by-pass circuitry in a separate compartment.
 2. Provide a door fused disconnect with Type "J" fuses, with a through-the-door handle, pad lockable in the OFF position. The door interlock shall be defeatable with a tool to allow service access without de-energizing the system. The disconnect shall remove power from all components within both compartments.
 3. Provide a three position "VFD/OFF/BY-PASS" switch to control VFD line side, VFD load side, and by-pass contactors. Contactors shall be interlocked to completely isolate the VFD in the by-pass mode for service.
 4. Provide control relays to operate by-pass contactor due to remote start/stop, safety interlock, or via the HAND-OFF-AUTO switch. See "Controls and Operation".
 5. Provide a three pole motor overload relay connected to shut down the motor in both the VFD and by-pass modes.
 6. 120V control power transformer with fused secondary and primary. Primary power shall be derived ahead of the VFD input contactor.
 7. Panel shall be arranged to allow power-off maintenance of the VFD while motor is operating on by-pass. By-pass or control circuitry in the same compartment as the VFD will not be allowed.
- D. Input Power:
1. The drive shall be capable of accepting facility power as specified on the drawings. Variations of up to plus or minus 10 percent of line voltage and plus or minus 2HZ of line frequency shall be permitted without the drive shutting down on a fault.
 2. Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault.
 3. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.
 4. The drive efficiency at rated load and frequency shall be 95 percent or better.

5. The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load.
 6. Manufacturer shall guarantee that harmonic voltage and current distortion, on the line side (input terminals) of the VFD does not exceed 5 percent total voltage Harmonic distortion, and 15 percent total current Harmonic distortion.
 - a. Manufacturer shall correct harmonic voltage and current distortion with an AC line reactor, an isolation transformer, or a tuned filter to stay within the above limit.
 - b. Manufacturer shall review electrical drawings to determine optimum characteristics of the reactor/filter system.
 - c. The installed drive shall be tested to verify the above distortion limits. The manufacturer shall replace the reactor/filter system if the installed drive does not meet the THD criteria. See Part 3.
- E. Output Power:
1. The variable frequency AC drive shall convert 3 phase, 60 HZ input power to an adjustable AC frequency and voltage for controlling the speed of any standard NEMA B Design, AC squirrel cage motors driving variable torque loads. The drive shall be rated for continuous duty at the NEC standard full load current of it's associated motor.
 2. Transistors (IGBT) to produce a sine weighted PWM three phase output for the load.
 3. The drive shall have sufficient capacity to provide stepless speed control of the motor throughout the operating range as specified herein.
 4. The drive output will be adjustable from 0 to 60 HZ.
 5. The drive shall have the capability to adjust the frequency above 4 kHz. The drive shall not operate with a frequency above 12 kHz.
 6. The IGBTs shall have a minimum rating of 1200 VDC on 480 V units and 600 VDC on 230 V units.
 7. The drive shall be suitable for operating at the altitude of the project location with no degradation or loss of performance.
- F. Control and Operation Features:
1. Adjustable acceleration and deceleration, with automatic acceleration rate limiting to avoid overload and automatic deceleration rate limiting to avoid excessive regeneration voltage.
 2. Speed/frequency settings to limit the maximum and minimum motor speed, to avoid up to 3 system critical resonance points and to provide a preset speed for operation in the event of loss of the remote speed signal.
 3. Capability to set drive to a pre-determined speed upon a contact closure input from the BAS.
 4. Capability of restarting into a rotating motor.
 5. The following operator control and monitoring functions shall be accessible without opening the door of the enclosure.
 - a. HAND/OFF/AUTO (or Local/Off/Remote) selector switch.
 - 1) With the "H-O-A" switch in the "HAND" or "LOCAL" position, the motor shall start in either VFD or by-pass mode as determined by VFD/OFF/BYPASS switch, and if in the "VFD" mode, the speed shall be controlled by the manual speed adjustment on the drive door.
 - 2) With the "H-O-A" switch in "AUTOMATIC" or "REMOTE", the motor shall start from the remote start/stop input in either VFD or by-pass mode as determined by the VFD/OFF/BYPASS switch and, if in the "VFD" mode, its speed shall be controlled by the BAS input speed signal.

- 3) With the "H-O-A" switch in the "OFF" position, the run circuit will be open and the VSC will not operate.
 - 4) This must be a physical switch, not a keypad input function.
 - b. Manual (local) speed adjustment.
 - c. Frequency (speed) indication.
 - d. Output amperage indication.
 - e. Pilot lights for:
 - 1) Power On (green)
 - 2) VFD Fault (red)
 - 3) External Fault (red)
 - 4) Motor on VFD (green)
 - 5) Motor on By-pass (red)
 - 6) Motor Overload (red)
6. The following control interfaces shall be provided:
 - a. Remote start/stop (run enable input)
 - 1) Provide a control relay and a terminal block in the by-pass compartment to allow remote start/stop in either the VFD or by-pass mode.
 - b. Remote speed input signal
 - 1) 4-20 mA, 0-5 VDC, 0-10 VDC, or as required by control system. Coordinate with 15971.
 - c. Safeties interlock input
 - 1) Provide a control relay and terminal block in the by-pass compartment to allow hardwired safety shutdown in either the VFD or by-pass mode.
 - d. Fault indication output contacts. Indicate fault for the following:
 - 1) Drive protection features
 - 2) Safety interlock
 - 3) Drive hardware fault
 - 4) Input power fault
 - 5) Others as provided by manufacturer
7. Provide a key pad and scrolling LCD display for operator interface with programming capabilities, fault diagnostics, fault reset, and security lockout code. Information shall be presented in plain English, not requiring codes.
 - a. Key pad shall be accessible without opening enclosure panel door.
8. In addition to the interlock and switches specified above, each variable frequency drive shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open and (2) two normally closed.

- G. Drive protection and safety features:
1. Ground fault protection.
 2. Electronic motor overload protection.
 3. Over-voltage/under-voltage protection.
 - a. The VFD shall be arranged to provide automatic restart after a trip condition resulting from over-voltage or under-voltage.
 - b. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts.
 4. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
 5. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
 6. Input phase loss and undervoltage protection.
 7. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
 8. High/over temperature protection.
 9. VFD shall include a "Bus Charged" warning indicator, and shall be provided with automatic circuitry to discharge the bus within 120 seconds after main power is disconnected.
- H. For drive manufacturers who use portable test meter for diagnostics, provide not less than one test meter for every five (5) variable frequency drives for each model or type used. Meters shall be supplied to the Owner upon completion of the project.
- I. Each drive shall include an RS 232 port with 25 pin "D" connector to allow downloading of parameter settings and fault history logs to a standard IBM compatible portable computer or printer. Software to allow download of setting shall be included.
- J. The audible dBa sound level of the complete system (motor & VFD) when operated over the full speed range shall be not more than 10 percent above the sound level of the motor operated in the by-pass mode (60 hZ building power). This test will be performed during initial startup. Corrections needed to achieve this requirement shall be made by the VFD supplier at not cost to the Owner.
- K. All variable frequency drives shall be warranted for 36 months after the building has been accepted by the Owner. This warranty shall include all parts, labor, materials, shipping cost, travel, lodging and meals with no cost to the Owner.
- 2.8 EQUIPMENT FABRICATION:
- A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 TEST AND TEST DATA:

- A. A factory load test shall be performed on each motor of 1000 watt input or greater to assure compliance with the energy-efficiency section of this specification.
- B. Typical test data on every motor to be used on this project shall be made available upon request.

3.2 INSTALLATION:

- A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.
- B. Deliver starters and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.
- C. Install power and control connections for motors to comply with NEC and applicable provisions of Division 16 sections. Install grounding except where non-grounded isolation of motor is indicated.
- D. Provide 4 inch high concrete housekeeping pad for floor mounted variable frequency drive.
- E. Where a separate disconnect switch is provided in the motor feeders between a VFD and the motor, provide an end switch at the disconnect to open the remote interlock shutdown circuit power circuit.

3.3 VFD START-UP SERVICES:

- A. Provide field start-up service by an authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up services shall include system check-out, start-up and system run.
- B. Start-up adjustments shall include optimizing frequency, optimizing volts/Hz ratio, identifying and avoiding resonant speeds, setting accel/decel ramps, and setting overload and circuit breaker trip points.

3.4 VFD HARMONIC DISTORTION TESTING:

- A. After installation is complete, measure the harmonic voltage and current distortion of each VFD with the drive assembly in by-pass mode, with the VFD running at 50 percent operating speed and with the VFD running at highest operating speed. Take measurements on each phase (L-L) on the line side (input terminals) of the VFD.
- B. If measurements exceed the limits as specified in Part 2, install corrective reactors or filters at no additional cost to the owner and retake measurements after corrective equipment is installed.

- C. Include all measurements (before and after) in the harmonic distortion report. Provide the Engineer with a copy of the harmonic distortion report.
 - D. The Harmonic Distortion Test and Report shall be conducted by an approved independent testing agency.
- 3.5 VFD NOISE TEST:
- A. Measure the dBa sound level of the motor with the drive in by-pass mode, and with the drive operating at 25 percent, 75 percent, and 100 percent speed output.
 - B. If the measurements exceed the limits specified in part 2, correct as required at no cost to the Owner, and retake measurements.
 - C. Report all tests to the Engineer.
- 3.6 VFD INDUCED SHAFT VOLTAGE TEST:
- A. After installation is complete, and system is operating under normal conditions, measure and report any voltage potential between the motor shaft and the motor frame, this test may occur anytime between substantial completion and the end of the overall project warranty period. Report findings to the Engineer. Costs for any corrective measures required shall not be included in the bid.
- 3.7 INSTALLATION COORDINATION:
- A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.
 - B. Verify windings of multi-speed or reduced voltage starters are compatible with the connected motor prior to installation.
 - C. All control wiring to be in accordance with manufacturer's recommendations; all wiring shall be color coded to facilitate checking.
 - D. It is the intent of this specification that one "General" Contractor enters an agreement with the Owner. The use and coordination of subcontractors is at the option of the General Contractor. All mechanical equipment, motors and controls shall be furnished, set in place, and wired. The schedule contained in Division 1 / 16 is provided as a guide only. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of the schedule is to have the Division 15 and 16 Contractors responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 16 for all electrical work which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Contractor shall refer to the Division 16 and Division 15 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

END OF SECTION 15040

SECTION 15050 - MECHANICAL SYSTEMS FIRE STOPPING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of firestopping required by this section is indicated on the drawings and by the requirements of this section.
- B. Types of firestopping systems specified in this section include:
 - 1. Bare metal pipe
 - 2. Insulated metal pipe
 - 3. Plastic piping
 - 4. Metal conduit
 - 5. Metal duct

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacturing of firestopping systems for mechanical/electrical penetrations, whose products have been in satisfactory use for not less than 5 years, with published application data for all types of penetrations to be encountered on this job, and with local representation capable of providing training and technical assistance at the job site.
- B. Installer's Qualifications: Personnel installing firestopping systems shall have been specifically trained by the manufacturer in the application of the materials to comply with the listing of the tested assembly.
- C. On-Site Training: The local manufacturer's representative shall conduct an on-site hands-on training seminar for all personnel involved in the installation of firestopping. The Engineer shall be invited to attend this training.
- D. Codes and Standards: Comply with the applicable codes pertaining to firestopping. Firestopping systems shall be tested and listed in accordance with the following:
 - 1. Underwriter's Laboratory:
 - a. UL 1479 test method for fire tests of through-penetration firestops.
 - b. UL Fire Resistance Directory
 - 2. American Society for Testing and Materials: ASTM E814-88 standard test method for fire tests of through-penetration firestops.

1.3 SUBMITTALS:

- A. Product Data: Manufacturer's specifications and technical data including the following:
 - 1. Detailed specification of construction and fabrication.
 - 2. Manufacturer's installation instructions.
- B. Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware and installation procedures, plus the following specific requirements:

1. Details of each proposed assembly, for all types of fire rated construction and penetrating items encountered, identifying intended products and applicable UL System Number, or UL classified devices.
 2. Manufacture or manufacturer's representative shall provide qualified engineering judgments and drawings relating to non-standard applications as needed.
- 1.4 DELIVERY, STORAGE AND HANDLING:
- A. Packing and Shipping:
 1. Deliver products in original, unopened packaging with legible manufacturer's identification.
 2. Coordinate delivery with scheduled installation date, allow minimum storage at site.
 - B. Storage and Protection: Store materials in a clean, dry ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.
- 1.5 PROJECT CONDITIONS:
- A. Existing Conditions:
 1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
 - B. Environmental Requirements:
 1. Furnish adequate ventilation if using solvent.
 2. Furnish forced air ventilation during installation if required by manufacturer.
 3. Keep flammable materials away from sparks or flame.
 4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
 5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS:
- A. Subject to compliance with the requirements of this specification, provide products by one of the following:
 1. 3M, Fire Protection Products
 2. Nelson Firestop Products
 3. Hilti Corporation
- 2.2 GENERAL:
- A. Provide fire stop systems listed in the UL Fire Resistance Directory. Provide systems with fire resistance "F" ratings equal to the fire resistance rating of the wall or floor assembly for all penetrations. In addition, provide systems with a "T" rating equal to the fire resistance rating of the wall or floor assembly in the following applications.
 1. Penetrating items larger than 4 inches diameter or 16 square inches in corridor walls.

2. Penetrating items larger than 4 inches diameter or 16 square inches when they are below the ceiling in any fire resistive wall.
3. Any floor penetrations not within a wall or chase.
4. All floor penetrations not within the cavity of a wall.

2.3 ACCESSORIES:

- A. Provide forming and damming materials and sleeves as required by the firestopping system installation instructions.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Review all project drawings, Owner's records and existing conditions to determine location, rating, and construction of all fire resistive construction.
- B. Coordinate location of penetrations to allow for the maximum and minimum annular space around the penetrating item. Allow a minimum of 1" undisturbed building material between penetrations, or provide a firestopping system listed for multiple penetrations. Penetrating items shall be centered in hole as much as practical, unless firestopping system is listed for point contact between the wall/floor assembly and the penetrating item.
- C. Neatly form, saw cut, hole saw or core drill openings. Size openings to conform with the maximum and minimum annular space requirements of the firestopping system.

3.2 APPLICATION:

- A. The Contractor shall determine the most appropriate firestopping system which complies with these specifications.
- B. All insulation shall be continued through the penetration. Provide intumescent caulk or collar firestopping systems. Where the insulation thickness specified in Section 15250 exceeds the allowable insulation thickness for the firestopping system, reduce the insulation thickness 6 inches on either side of the penetration. Do not reduce insulation to less than 50 percent of the specified thickness.
- C. Provide collar type firestopping systems where shown on drawings, and for hot piping systems at penetrations where significant thermal movement can be expected, such as near expansion compensation loops or joints.
- D. Provide a firestopping system for ducts penetrating fire resistive construction without fire or fire/smoke dampers.
 1. Do not provide firestopping between fire or fire/smoke damper sleeves and the opening.
- E. Anchor wiring not within conduit on each side of a penetration to prevent it from being pulled out of the firestopping system.
- F. See Section 15120 for sleeves. The use of sleeves may affect the "T" rating of the firestopping system. Coordinate use of sleeves with firestopping.

END OF SECTION 15050

SECTION 15055 - BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUBMITTALS:

- A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.
- B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.
- C. Welding Certifications: Submit reports as required for piping work.
- D. Brazing Certifications: Submit reports as required for piping work.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.
- C. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as follows: B31.1 - Pressure Piping Code / B31.2 - Fuel Gas Piping Code / B31.5 - Refrigeration Piping / B31.9 - Building Service Piping Code.
- D. Before any welding is performed, the contractor shall submit to the Architect/Engineer, or his authorized, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests and his Welding Procedure Specification together with the Procedure Qualification Record as required by ASME Boiler and Pressure Vessel Code.
- E. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.
- F. Soldering and Brazing procedures shall conform to ANSI Standard Safety Code for Mechanical Refrigeration.

PART 2 PRODUCTS

2.1 GENERAL:

- A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.
- B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated,

comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 STEEL PIPES AND PIPE FITTINGS:

- A. Black Steel Pipe: ASTM A 53, Grade B, type E, electric resistance welded.
- B. Galvanized Steel Pipe: ASTM A 53, Grade B.
- C. Seamless Steel Pipe: ASTM A 53, Grade B, type S or A106 high temperature.
- D. Cast-Iron Flanged Fittings: ANSI/ASME B16.1, including bolting (Class 125 and 250).
- E. Cast-Iron Threaded Fittings: ANSI/ASME B16.4 (Class 125 and 250).
- F. Malleable-Iron Threaded Fittings: ANSI/ASME B16.3; plain or galvanized as indicated (Class 125 and 300).
- G. Malleable-Iron Threaded Unions: ANSI B16.39, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).
- H. Threaded Pipe Plugs: ANSI/ASME B16.14.
- I. Steel Flanges/Fittings: ANSI/ASME B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.

Material Group: Group 1.1.
End Connections: Buttwelding.
Facings: Raised-face.

- J. Steel Pipe Flanges for Waterworks Service: AWWA C207 (water service piping only).
- K. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing (threaded where pressure is not critical).
- L. Forged-Steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe (up to 4 inch pipe size).
- M. Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.
- N. Stainless-Steel Buttwelding Fittings: MSS SP-43.
- O. Cast-Iron Threaded Drainage Fittings: ANSI B16.12.
- P. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.
- Q. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2 inches, and where pipe size is less than 1-1/2 inches, and do not thread nipples full length (no close-nipples).

2.3 COPPER TUBE AND FITTINGS:

- A. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn temper, except as otherwise indicated.
- B. DWV Copper Tube: ASTM B 306.
- C. ACR Copper Tube: ASTM B 280.
- D. Cast-Copper Solder-Joint Fittings: ANSI B16.18.
- E. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.
- F. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).
- G. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.
- H. Cast-Copper Flared Tube Fittings: ANSI B16.26.
- I. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300).
- J. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.4 BRASS PIPE AND FITTINGS:

- A. Red Brass Pipe: ASTM B 43 (boiler feed pipe, 1/8 inch thru 12 inches, regular or extra strong weight).
- B. Cast-Bronze Threaded Fittings: ANSI B16.15, Class 125 or 250.
- C. Cast-Bronze Threadless Fittings: ASTM B 61 or B 62, brazed joints.

2.5 CAST-IRON PRESSURE PIPES AND PIPE FITTINGS:

- A. Ductile-Iron Pipe: Class 52, ANSI A21.51; AWWA C151; 350 psi pressure rating.
- B. Cast-Iron Fittings: ANSI/AWWA C110/A21.10.
- C. Ductile-Iron Fittings: ANSI/AWWA C110/A21.10.
- D. Rubber-Gasket Joints: ANSI/AWWA C111/A21.11.

2.6 CAST-IRON SOIL PIPES AND PIPE FITTINGS:

- A. Hubless Cast-Iron Soil Pipe: FS WW-P-401 and CISPI Standards 301 and 310. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.
- B. Cast-Iron Hub-and-Spigot Soil Pipe: ASTM A 74. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.
- C. Hubless Cast-Iron Soil Pipe Couplings: Neoprene gasket complying with ASTM C564, CISPI Standard 310 and stainless steel clamp holding band.
- D. Heavy Duty Hubless Cast Iron Soil Pipe Couplings: Neoprene gasket coupling with ASTM C564. 304 stainless steel shield, minimum 0.15 inches thick, minimum 3 inches wide with 4 sealing bands up to 4 inch pipe, minimum 9 inches wide with 6 sealing bands up to 10 inch pipe.
 - 1. Basis of Design: Husky SD 4000.
- E. Cast-Iron Hub-and-Spigot Soil Pipe Fittings: Match soil pipe units; complying with ASTM A 74.
- F. Neoprene Compression Gaskets: ASTM C 564.

2.7 PLASTIC PIPES AND PIPE FITTINGS:

- A. Acrylonitrile-Butadiene-Styrene Sewer Pipe (ABS): ASTM D-1527, 3 inch thru 12 inch; SDR 23.5, 4 and 6 inch; SDR 35, 3 inch, 4 inch, and 6 inch; SDR 42, 8 inches, 10 inch and 12 inch.
- B. ABS Pipe Fittings:
 - Schedule 40 Socket: ASTM D 2468.
 - Schedule 80 Socket: ASTM D 2469.
 - Schedule 80 Threaded: ASTM D 2465.
 - Solvent Cement: ASTM D 2235.
 - Solvent Cement (To Join ABS To PVC): ASTM D 3138.
- C. Polyvinylchloride Sewer Pipe (PVC): ASTM D-2729, 2 inch thru 6 inch; ASTM D2665, 1-1/2 inches thru 8 inches.

2.8 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

- A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.
 - 1. Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.
- B. Soldering Materials: All soldering materials shall be lead free.
 - 1. 95-5 Tin-Antimony: ASTM B 32, Grade 95TA. Melting Range 450-470 degrees F.
 - 2. Silver-Tin Alloy: Fed. Spec. QQ-S-571E, NSFC2. Melting Range 430 to 530 degrees F.
 - 3. Flux: All flux shall be lead free, water soluble, and compatible with the solder and the materials being joined. ASTM B813-93.
- C. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.
 - 1. Comply with AWSA 5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
 - a. Copper phosphorus -Bcup-5, 15 percent solver content, melting range 1190 to 1480 degrees F.
 - b. Silver - BAg-36, 45 percent silver, cadmium-free. Melting range 1195 to 1265 degrees F.
- D. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.
- E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.
 - 1. Manufacturer: Subject to compliance with requirements, provide piping connectors of the following:

- a. Husky Technologies (Husky SD 4000):
- F. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.
 1. Manufacturer: Subject to compliance with requirements, provide piping thread sealant material of the following:
 - a. The Rectorseal Corporation

PART 3 EXECUTION

3.1 EXAMINATION:

- A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, and original design, and the referenced standards.
- B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:

- A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16 inch misalignment tolerance.
 1. Comply with ANSI B31 Code for Pressure Piping.
 2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.
 3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.
 4. Use fittings for all changes in direction and all branch connections.
 5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.
 6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.
 7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
 9. Install drains in pressure pipe systems at all low points in mains, risers, and branch lines consisting of a tee fitting, $\frac{3}{4}$ inch ball valve, and short $\frac{3}{4}$ inch threaded end nipple and cap with chain.
 10. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.
 11. Fire and Smoke Wall Penetrations: Where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity. Refer to Division 15, Section 15120 and 15050 for materials.
 12. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals (See Section 15120). Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.
 13. Anchor piping to ensure proper direction of expansion and contraction.
 14. Coordinate foundation and all other structural penetrations with structural engineer.
- B. Hydronic Piping:
1. Make reductions in hydronic pipe sizes using eccentric reducer fitting installed with the level side up.
 2. Install hydronic piping branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line. Install all hydronic piping level with manual air vent at all high points in direction of flow.
 3. Install hydronic piping level except for gravity flow systems such as condenser water and condensate drain piping.
- C. Sanitary Waste and Vent; Roof Drain and Storm Drain Piping:
1. Install plumbing drainage piping with $\frac{1}{4}$ inch per foot (2 percent) downward slope in direction of drain for piping 3 inches and smaller, and $\frac{1}{8}$ inch per foot (1 percent) for piping 4 inch and larger. Install cast iron pipe in accordance with the Cast Iron Soil Pipe Institute Handbook.
 2. Install 1 inch thick extruded polystyrene over underground drainage piping that is above frost line and not under building. Provide width to extend minimum of 12 inches beyond each side of pipe. Install directly over pipe, centered on pipe center line.
 3. Make changes in direction for drainage and vent piping using appropriate 45 degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. **SANITARY CROSSES OR SHORT QUARTER BENDS SHALL NOT BE USED IN DRAIN PIPING.**
 4. Provide thrust restraints (bracing to structure or rodded joints) at branches and changes in direction for cast iron pipe 5 inches and larger suspended within the building.
 5. Where cast iron piping is suspended in excess of 18 inches on single rod hangers, sway bracing shall be provided to prevent shear at the joints.

6. Install underground drain piping to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual.
7. Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.
8. Place bell ends or groove ends of piping facing upstream.
9. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.
10. Install sub-surface drain piping according to requirements of the soils engineers requirements when required and connect to storm sewer / sump pump.
11. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.
12. Remove unstable, soft, and unsuitable materials at the surface upon which pipes shall be laid, and backfill with clean sand or pea gravel to indicated invert elevation.
13. Shape bottom of trench to fit the bottom 1/4 of the circumference of pipe. Fill unevenness with tamped sand. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

D. Refrigerant Piping:

1. General: Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration."
2. Install piping in as short and direct arrangement as possible to minimize pressure drop.
3. Install piping for minimum number of joints using as few elbows and other fittings as possible.
4. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.
5. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.
6. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.
 - a. Do not install insulation until system testing has been completed and all leaks have been eliminated.
7. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.
8. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

9. Slope refrigerant piping as follows:
 - a. Install horizontal hot gas discharge piping with 1/2 inch per 10 feet downward slope away from the compressor.
 - b. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
 - c. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.
 - d. Liquid lines may be install level.

E. Condensate Drain Piping:

1. Condensate drain piping from air conditioning unit coil condensate drain pan shall be of the sizes shown on the drawings.

F. Plastic Pipe:

1. All plastic piping installed below grade shall meet ASTM D2321-89 requirements.

3.3 PIPING SYSTEM JOINTS:

- A. General: Provide joints of type indicated in each piping system.
- B. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.
- C. Braze copper tube-and-fitting joints in accordance with ASME B31.
- D. Solder copper tube-and-fitting joints with silver solder or 95-5 tin-antimony. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.
- E. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.
- F. Weld pipe joints in accordance with recognized industry practice and as follows:
 1. Weld pipe joints only when ambient temperature is above 0 degrees F (-18 degrees C) where possible.
 2. Bevel pipe ends at a 37.5 degrees angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
 3. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inch to 20 inch.

4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.
 5. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.
- G. Weld pipe joints of steel water pipe in accordance with AWWA C206.
- H. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.
- I. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions. Use pre-set torque wrench set to 80 in-lbs on heavy duty couplings.
- J. Clay Pipe Joints: Comply with ASTM C 12.
- K. Concrete Pipe Joints: Except as otherwise indicated, comply with applicable provisions of "Concrete Pipe Field Manual" by the American Concrete Pipe Assn.
- L. Corrugated Metal Pipe Joints: Comply with manufacturer's instructions and recommendations.
- M. Open Drain-Tile Joints: Except as otherwise indicated, provide 1/4 inch open joint, with top 2/3 of annular space covered by joint accessory material.
- 3.4 PIPING APPLICATION:
- A. Domestic Hot and Cold Water - Inside Building:
1. Above Grade Inside Building:
 - a. 6 inches and Smaller: Type L / K, hard drawn copper tube with wrought copper or bronze fittings, 95-5 tin-antimony / silver tin alloy soldered joints.
- B. Sanitary Drainage and Vents - Inside Building:
1. Above Grade: Service weight cast iron, no-hub type with neoprene gaskets; service weight cast iron, hub and spigot type with neoprene gaskets; or DWV copper with wrought copper or cast brass fittings.
 2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type only with neoprene compression gaskets; or sizes 12 inches and larger ductile cast iron with neoprene gasket joints.
- C. Sanitary Sewer - Beyond 5 feet Outside Building: Extra strength vitrified clay pipe hub and spigot type with resilient gasket joints or type ASTM D2665 SDR-35 PVC Sewer Pipe; sizes 12" and larger ductile cast iron with neoprene gaskets; or service weight cast iron, hub and spigot type with neoprene gaskets.
- D. Roof Drainage - Inside Building:
1. Above Grade:

- a. 30 foot head or less: Service weight cast iron, hub and spigot type or no-hub Husky Series 4000 (or equivalent); or galvanized steel with galvanized cast iron drainage fittings and threaded joints.
 - b. Over 30 foot head: Schedule 40 galvanized steel pipe with galvanized cast iron drainage fittings and threaded joints; or schedule 40 grooved galvanized steel pipe joined with rigid couplings and gaskets designed for water service, molded of materials conforming to ASTM D-2000; or ductile iron, thickness 52 or ANSI/AWWA C150/A21.50-81, 350 psi pressure rating. Full lengths of pipe shall be utilized to greatest extent possible.
2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type or sizes 12 inches and larger ductile cast iron with neoprene gasket joints.
- E. Storm Sewer - Beyond 5 feet Outside Building: Extra strength vitrified clay pipe; hub and spigot type or ASTM D3034 SDR-35 PVC sewer pipe, sizes 12 inches and larger ductile cast iron with neoprene gasket joints; or service weight cast iron, hub and spigot type with neoprene gaskets.
- F. Accessible Gas Piping:
1. Above Grade:
 - a. Exposed Location:
 - 1) 2 Inches and Smaller: Schedule 40, black steel pipe, beveled ends, with 150 lb. malleable iron fittings and threaded joints.
 - 2) Over 2 Inches: Schedule 40 black steel with butt weld fittings and welded joints.
 - b. Inaccessible Location:
 - 1) All sizes: Schedule 40 black steel pipe, beveled ends, with socket weld fittings same thickness as pipe; welded joints.
 2. Below Grade: Schedule 40 seamless black steel with 150 lb. forged steel fittings and welded joints. Provide machine applied, coated and wrapped pipe in accordance with local code and utility company requirements. Provide cathodic protection as called for on the drawings.
- G. Heating Water and Chilled Water Piping:
1. 2 Inches and Smaller:
 - a. Schedule 40, black steel with 125 lb. cast iron or 150 lb. malleable iron threaded fittings.
- OR
- Type L / K copper, hard drawn copper wrought copper or bronze fittings, silver - tin alloy solder joints.
2. 2-1/2 Inches and Larger:

- a. Schedule 40, seamless or ERW (std. weight 12 inches and over) black steel with flanged or welded joints.
 - b. Fittings: Standard weight / Extra strong, seamless steel, butt weld type.
 - c. Flanges: 150 lb. 300 lb. forged steel slip-on or welding neck type.
 - d. Bolting: Regular square head machine bolts with heavy hexagonal nuts.
 - e. Gaskets: Thickness, material and type suitable for fluid to be handled, and design temperature and pressures.
- H. Equipment Drains and Overflows:
1. Type "M" or "DWV" copper.
- I. Refrigerant Piping:
1. Type "L" ACR copper, cleaned, dehydrated and capped at the factory. Wrought copper fittings with brazed joints.
- J. Diesel Generator Exhaust:
1. Schedule 40 (std. weight 12 inches and over), black steel with all welded joints.

3.5 PIPING TESTS:

- A. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.
- B. Test all piping systems as specified. Correct leaks by remaking joints. Remove equipment not able to withstand test procedure during test.
- C. Work to be installed shall remain uncovered until the required tests have been completed.
- D. Piping which is to be concealed shall be tested before being permanently enclosed.
- E. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.
- F. Give a minimum of twenty-four hours notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of owner, agency having jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.
- G. Contractor shall obtain certificates of approval, acceptance and compliance with regulations of agencies having jurisdiction. Work shall not be considered complete until such certificates have been delivered by the Engineer to the Owner.
- H. All costs involved in these tests shall be borne by Contractor.

I. System Tests

1. Hydrostatic Test: The test shall be accomplished by hand pumping the system to the specified water pressure, and maintaining that pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four hours.
 - a. Domestic water systems: 100 psig or 150 percent of system pressure, whichever is greater.
 - b. Heating water: 100 psig or 150 percent of operating pressure, whichever is greater.
 - c. Chilled water: 100 psig or 150 percent of system pressure, whichever is greater.
2. Compressed Air or Nitrogen Test: Compressed air tests may be substituted for hydrostatic tests only when ambient conditions or existing building conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing. For tests of this type, the piping system shall be subjected to the gas pressure indicated for that specific system. The piping capped or plugged and water-pumped with oil free air, or a nitrogen bottle shall be introduced into the entire system to the pressure specified. The system shall maintain that pressure for the duration of a soapy water test of each joint.
3. Waste, Drain and Vent Piping: All waste and vent piping, including building drain, roof drain and building sewer, shall be subjected to a water test. All openings in the piping system shall be tightly closed, except the highest opening, and the system filled with water to the point of overflow. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before inspection starts; the system shall then be tight to all points. No section shall be tested with less than a ten foot head of water. Roof drain shall be closed at the lowest point and filled with water to the point of overflow.
4. Test all refrigerant piping systems with nitrogen at 300 psig pressure on high side of system, and at 150 psig pressure on low side of system. Maintain pressure without loss for a time period of not less than 4 hours. After test has been completed, the piping shall be evacuated by means of a vacuum pump for a period of not less than 24 hours or until system has been completely evacuated.
5. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
6. Drain test water from piping systems after testing and repair work has been completed.

3.6 UNDERGROUND PIPE INSTALLATION:

- A. Clean fittings, nipples and other field joints thoroughly before coating.
- B. Protect gray and ductile cast iron pipe installed below grade with polyethylene encasement applied in strict accordance with ANSI/AWWA C105/A21.5.
- C. Install ductile iron pipe below grade as prescribed by AWWA C600.
- D. Provide concrete thrust block and 3/4 inch steel threaded tie bar at each direction change on underground pressure pipe. Imbed tie bar in thrust block and connect to upstream fitting. Paint tie bar with two coats of bitumastic #50 paint.

- E. Bury all outside water piping minimum 5 feet-0 inches below grade to top of pipe.

3.7 ADJUSTING AND CLEANING:

- A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.
 - 1. Inspect pressure piping in accordance with procedures of ASME B31.
- B. Disinfect all potable water mains and water service piping in accordance with local and health department requirements. Submit test results report.
- C. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
- D. Chemical Treatment: Provide hydronic systems with a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.8 COMMISSIONING:

- A. Fill system and perform initial chemical treatment.
- B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
- C. Before operating the system perform these steps:
 - 1. Open valves to full open position. Close coil bypass valves.
 - 2. Remove and clean strainers.
 - 3. Check pump for proper rotation and proper wiring.
 - 4. Set automatic fill valves for required system pressure.
 - 5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
 - 6. Set temperature controls so all coils are calling for full flow.
 - 7. Check operation of automatic bypass valve.
 - 8. Check and set operating temperature of boilers, chillers, and cooling towers to design requirements.
 - 9. Lubricate motors and bearings.

END OF SECTION 15055

SECTION 15100 - VALVES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. This Section includes general duty valves common to most mechanical piping systems.
- B. Valves tags and charts are specified in Division 15 Section "Mechanical Identification."

1.2 SUBMITTALS:

- A. Product Data: including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.3 QUALITY ASSURANCE:

- A. Single Source Responsibility: Comply with the requirements specified in Division-15 Section "Basic Mechanical Requirements," under "Product Options."

- B. MSS Standard Practices: Comply with the following standards for valves:

- 1. MSS SP-45: Bypass and Drain Connection Standard
- 2. MSS SP-67: Butterfly Valves
- 3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
- 4. MSS SP-71: Cast Iron Swing Check Valves, Flanged and Threaded Ends
- 5. MSS SP-72: Ball Valves with Flanged or Butt-Welding Ends For General Service
- 6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
- 7. MSS SP-80: Bronze Gate, Globe Angle and Check Valves
- 8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
- 9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
- 10. MSS SP-92: MSS Valve User Guide

- C. Solenoid valves shall be UL listed, FM / AGA / ANSI and CSA approved.

1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Preparation For Transport: Prepare valves for shipping as follows:

- 1. Ensure valves are dry and internally protected against rusting and galvanic corrosion.
- 2. Protect valve ends against mechanical damage to threads, flange faces, and weld end preps.
- 3. Set valves in best position for handling. Globe, and gate valves shall be closed to prevent rattling; ball and plug valves shall be open to minimize exposure of functional surfaces; butterfly valves shall be shipped closed or slightly open; and swing check valves shall be blocked in either closed or open position.

- B. Storage: Use the following precautions during storage:

- 1. Valves shall be stored and protected against all dirt, debris and foreign material at all times.

2. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.
 3. Protect valves against weather. Where practical store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement and protect in watertight enclosures.
- C. Handling: Valves whose size requires handling by crane or lift shall be slung or rigged to avoid damage to exposed valve parts. Handwheels and stems, in particular, shall not be used as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by the manufacturers listed.
1. Gate Valves:
 - a. Stockham
 - b. Grinnell Corp.
 - c. Hammond
 - d. Nibco
 - e. Milwaukee
 2. Ball Valves:
 - a. Conbraco (Apollo)
 - b. Milwaukee
 - c. Nibco
 - d. Watts
 - e. Jomar
 3. Eccentric Plug Valves:
 - a. Keystone/Tyco
 - b. DeZurik
 - c. Milliken
 - d. Homestead
 4. Globe Valves:
 - a. Stockham
 - b. Grinnell Corp.
 - c. Hammond
 - d. Nibco
 - e. Milwaukee
 5. Butterfly Valves:
 - a. Keystone/Tyco
 - b. Centerline
 - c. Nibco

- d. K.F. Hale
 - e. Bray
6. Swing Check Valves
- a. Conbraco
 - b. Grinnell Corp.
 - c. Nibco
 - d. Watts (screwed)
 - e. Stockham
 - f. Grinnell (Grooved Only)
7. Non-Slam Check Valves:
- a. Centerline
 - b. Keystone
 - c. Metraflex
 - d. Techno Corporation
 - e. Nibco
 - f. Val-Matic
 - g. Milwaukee
 - h. Stockham
 - i. Golden Anderson
8. Lift Check Valves:
- a. Conbraco
 - b. Metraflex
 - c. Milwaukee
 - d. Nibco
 - e. Stockham
9. Solenoid Valves:
- a. Asco
 - b. General Controls
 - c. Skinner
 - d. Magnatrol Valve Corp.
- 2.2 VALVE FEATURES:
- A. General: Comply with MSS-92 1980 "Valve Users Manual".
 - B. Valve Design: Valves shall have rising stem, or rising stem outside screw and yoke design; except, non-rising stem valves may be used where headroom prevents full operation of rising stem valves.
 - C. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size. (Control valves shall be sized for required flow.)
 - D. Operators: Provide the following special operator features:
 - 1. Handwheels, fastened to valve stem for valves other than quarter turn.

2. Lever Handle on quarter turn valves 6 inch and smaller, except plug valves. Provide a wrench for every plug valve.
 3. Worm gear operators of an enclosed weather-proof design shall be provided on all quarter turn valves 8 inches and larger.
- E. Extended Stems: Where insulation is indicated or specified, provide extended stems to allow full operation of the valve without interference by the insulation.
- F. Bypass and Drain Connections: Comply with MSS SP-45.
- G. End Connections: As specified in the individual valves specifications.
1. Threads: Comply with ANSI B2.1.
 2. Flanges: Comply with ANSI B16.1 for cast iron, ANSI B16.5 for steel, and ANSI B16.24 for bronze.
 3. Solder-Joint: Comply with ANSI B16.18.
 - a. Caution: Where soldered end connections are used, use solder having a melting point below 840 degrees F for gate, globe, and check valves and below 421 degrees F for ball valves.

2.3 GATE VALVES:

- A. Gate Valves – 2 inches and Smaller: MSS SP-80, Class 150 , body and bonnet of cast bronze ASTM B62 for 150#, threaded ends, solid wedge disc, union bonnet, rising stem, bronze gland, TFE impregnated packing, malleable iron handwheel.

Stockham Fig. B-120/B-124

- B. Gate Valves - 2-1/2 inches and Larger: MSS SP-70, Class 125, iron body conforming to ASTM A126 C1 B, Bronze trim, O S & Y design, Flanged ends, TFE impregnated packing.

Stockham Fig. G-623

2.4 BALL VALVES:

- A. Ball Valves – 1 inch and Smaller: 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F, two piece end entry body style, bronze body conforming to ASTM B584, full port chrome plated brass ball, 15 percent glass reinforced PTFE seats, PTFE packing, adjustable packing nut blow-out proof stem, vinyl covered steel handle. Provide solder ends or threaded ends to match piping system. Apollo 77-100/200
- B. Ball Valves 1-1/4 inch through 2 inches and for all silver soldered or brazed lines: ANSI B16.34, 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F. Three piece body style, bronze body conforming to ASTM B584, full port, chrome plated brass ball and stem of ASTM A276 type 316, 15 percent glass reinforced RTFE seats, RTFE packing and blow out proof stem, vinyl coated steel handle. Provide solder ends or threaded ends to match piping material system. Apollo 82-100/200.
- C. Ball valve options/accessories: Provide the following as required or as specifically indicated:
1. Tee handle for tight fit applications (within enclosures, etc.).

2. Locking handle.
3. Drain.
4. Stem extension.
5. Mounting pads.

2.5 ECCENTRIC PLUG VALVES:

- A. 2 inches and Smaller: 125 psi, cast iron body, straightway pattern, EPDM or C11R Encapsulated Eccentric plug, tight shut-off seals, square head, threaded ends. Provide memory stop feature.

Dezurik PEC

- B. 2-1/2 inches and Larger Sizes: 125 [] psi, cast iron body, straightway pattern, EPDM or C11R Encapsulated Eccentric plug, lever actuators, except handwheels where indicated, and flanged ends. Provide memory stop feature.

Dezurik PEC

NOTE: An eccentric plug valve with memory stop may be installed for combination shut-off/balancing service in lieu of a separate balancing valve plus shut-off valve installation at Contractor's option.

2.6 GLOBE VALVES:

- A. Plumbing Systems (2-1/2 inches and Smaller): MSS SP-80, Class 125 WSP body, bonnet and disc cast bronze ASTM B62, copper-silicon bronze stem, non-asbestos teflon impregnated stem packing, bronze disc ring, threaded bonnet and malleable iron handle.

Stockham Fig. B-16/B-17

2.7 BUTTERFLY VALVES:

- A. Hydronic Service Butterfly Valves - 2-1/2 inches to 12 inches: MSS SP-67, cast iron body conforming to ASTM A126 class B, aluminum bronze ASTM B148 disc, single piece 416 stainless steel stem, EPDM seat, upper and lower bronze bearing, non-metallic bushing and stem seal, ANSI class 125 flange, rated for 200 psi pressure differential, 200 psi drop-tight shut off dead end service, with downstream flange removed. Provide extended neck for 2 inches thick insulation. All valves shall be factory tested to 110 percent of pressure rating. All butterfly valves shall be full lugged body, drilled and tapped.

Keystone Fig.222

2.8 CHECK VALVES:

- A. Swing Check Valves - 2-1/2 Inch and Smaller: MSS SP-80; Class 125/150 WSP 200/300, cast bronze body and cap conforming to ASTM B 62, ASTM B61 for 200/300 bronze, horizontal swing design, Y-pattern, with a bronze/teflon disc, stainless steel pin and having threaded or solder ends. Class 150 valves meeting the above specifications may be used where pressure requires or Class 125 are not available.

- B. Swing Check Valves - 2-1/2 to 3 Inch: MSS SP-71; Class 125 /250 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

- C. Non-Slam Check Valves - 2 Inch and smaller: Bronze body, 200 psi @ 250 degrees F., threaded ends, resilient seats, center guided spring loaded disk.
- D. Non-Slam Check Valves - 2-1/2 Inch and Larger: Class 125/ 250 cast iron or stainless steel body, replaceable lapped bronze seat and balanced twin bronze flappers or bronze center guided disc and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers or center guided disc shall be loaded with a stainless steel spring to assure even non-slam checking action. Seals shall be EPDM.
- E. Lift Check Valves 2 Inch and Smaller: Class 125 [], cast bronze body and cap conforming to ASTM B 62, horizontal or angle pattern, lift type valve, with stainless steel spring, bronze disc holder with renewable "Teflon" disc, and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

2.9 DRAIN VALVES: FOR HVAC AND PLUMBING HYDRONIC SYSTEMS PROVIDE BALL VALVE WITH THREADED HOSE END, AND CAP WITH CHAIN.

Apollo Fig. 78-100/78-200 Series

2.10 SOLENOID VALVES:

- A. Solenoid valves shall consist of a solenoid (electro-magnet) with its core and a valve body containing one or more orifices. The solenoid shall be mounted directly on the valve body.
- B. Response time from fully open or closed to fully closed or open shall be slow acting.
- C. Solenoid valves shall be 2 / 3 / 4 way type valves.
- D. Solenoid valves shall be normally open or normally closed operation as required for proper operation of the system for protection against freeze, fire and safety.
- E. Solenoid enclosures shall meet the ICS-6 ANSI/NEMA standard and UL standard 429, 508 and/or 1002 as follows:
 - 1. Type 1: General Purpose.
 - 2. Type 2: Drip proof.
 - 3. Type 3 and 3S: Raintight, Dust tight and sleet (ice) resistant.
 - 4. Type 3R: Rainproof, sleet (ice) resistant
 - 5. Type 4: Watertight and dust tight.
 - 6. Type 4X: Watertight, Dust tight and Corrosion resistant.
 - 7. Type 6: Submersible.
 - 8. Type 6P: Submersible, prolonged submersion at a limited depth.
 - 9. Type 7: Explosion proof, Class I, Division 1, Group A (acetylene); B (hydrogen); C (ethyl-ether vapors, ethylene or cyclopropane); D (gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, solvent vapors or natural gas).
 - 10. Type 9: Dust-ignition proof, Class II, Group E (metal dust); F (carbon black coal or coke dust); G (flour starch or grain dust).
 - 11. Operating temperatures shall range from 185 degrees F to 842 degrees F for T1 through T6 code numbers.
- F. Minimum ambient temperature limitation of 32 degrees F (0 degrees C) for any valve which contains water or water vapor and 0 degrees F (-18 degrees C) where freezing water is not a factor. (Special construction for ambient temperature down to -40 degrees F (-40 degrees C). Maximum ambient temperature limitation of 180 degrees F (82 degrees C).

- G. Parts in contact with fluid shall be brass, bronze, or stainless steel; core tube, 305 stainless steel; core and plug nut, 430 F stainless steel; Seal-BUNA "N"; shading coil-copper; disc-BUNA "N" and Nylon; Spring, 302 stainless steel (General Service).
- H. Manual reset safety shut-off valve shall open manually and close upon interruption of current.
- I. Electric current shall be AC of voltage shown on Division 16 drawings.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Install valves in accordance with manufacturers instructions.
- B. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.
- C. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.
- D. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.
- E. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.
- F. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

3.2 VALVE SELECTION:

- A. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:
 - 1. Copper Tube Size 2 Inch and Smaller: Solder ends, except in heating hot water and low pressure steam service which shall have threaded ends.
 - 2. Steel Pipe Sizes 2 Inch and Smaller: Threaded or grooved-end.
 - 3. Steel Pipe Sizes 2-1/2 Inch and Larger: Flanged or grooved end.
 - 4. At all piping hot taps provide a gate valve with the hot tap and a butterfly valve for shut-off service. Hot taps shall be provided only where approved by the Engineer.

3.3 VALVE INSTALLATIONS:

Valve Application Table

(Where sizes overlap, contractor has choice of either type)

SERVICE	VALVE TYPE
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Plumbing Water Services; 3" or smaller	Ball Valve
Plumbing Water Services; 2-1/2" and larger	Butterfly Valves
Plumbing Pressure Reducing Bypass; all sizes	Globe Valve
Plumbing Balancing Service; 2" and smaller	Calibrated Balancing Valve See Section 15135
Plumbing Balancing Service; 2-1/2" and larger	Eccentric Plug Valve
HVAC Hydronic Piping; 3" and smaller	Ball Valve
HVAC Hydronic Piping; 2-1/2" and larger	Butterfly Valve
HVAC Hydronic Pressure Reducing Valve Bypass; all sizes	Globe Valve
HVAC Hydronic Balancing valve; 2" and smaller	Calibrated Balancing Valve See Section 15135
HVAC Hydronic Balancing Valve; 2-1/2" and larger	Eccentric Plug Valve.
HVAC & Plumbing Check Valves; 2" and smaller	Swing Check
HVAC & Plumbing Pump Discharge Check Valve;	Non-Slam Spring Loaded

- A. Locate valves for easy access and provide separate support where necessary.
- B. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
- C. Install 3-valve bypass around each pressure reducing valve using throttling type valves.
- D. Gate and globe valves shall be installed with the stem in the upright position. In overhead horizontal piping, ball valves shall be installed with the handle in the side or bottom of the piping. Butterfly valves shall be installed with the stem within 45 degrees of the horizontal position. The handle of quarter turn valves shall open in the direction of flow. Quarter turn valves with hand wheels or chain wheels shall be located so that the position indicator is visible from the floor without the use of a ladder or climbing on equipment or piping.
- E. Installation of Check Valves: Install for proper direction of flow as follows:
 - 1. Swing Check Valves: Install in horizontal position with hinge pin level.
 - 2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical upward flow position.
 - 3. Lift Check Valve: Install in piping line with stem upright and plumb.

3.4 SOLDER CONNECTIONS:

- A. Cut tube square and to exact lengths.
- B. Clean end of tube to depth of valve socket, using steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.
- C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.
- D. Open gate and globe valves to fully open position.
- E. Remove the cap and disc holder of swing check valves with composition discs.

- F. Insert tube into valve socket making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to insure even distribution of the flux.
- G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating the valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 BRAZED CONNECTIONS:

- A. Protect valves from temperatures which exceed the valve material temperature limitations as recommended by the valve manufacturer.
- B. Disassemble 3 piece ball valves prior to brazing.

3.6 THREADED CONNECTIONS:

- A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
- B. Align threads at point of assembly.
- C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
- D. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.7 FLANGED CONNECTIONS:

- A. Align flanges surfaces parallel.
- B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

3.8 GROOVED CONNECTIONS:

- A. Assemble valves with grooved end in accordance with manufacturers published instructions.
- B. Clean pipe ends from indentations, projections, burrs and roll marks from pipe to groove.
- C. Provide gasket, flanges, fittings, bolts, nuts, lubrication applied per manufacturers instructions for intended service.

3.9 FIELD QUALITY CONTROL:

- A. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

3.10 ADJUSTING AND CLEANING:

- A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive finish painting or insulation.

END OF SECTION 15100

SECTION 15120 - PIPING SPECIALTIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-15 sections.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".
 - 2. ASME B 31.9 "Building Services Piping" for materials, products, and installation.
 - 3. Safety valves and pressure vessels shall bear the appropriate ASME label.
 - 4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
 - 5. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.
- B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Divisions 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Combination Pressure and Temperature Relief Valves:

- a. Amtrol, Inc.
- b. Bell & Gossett ITT; Fluid Handling Div.
- c. Spirax Sarco.
- d. Watts Regulator Co.

2. Pressure Reducing Valves:

- a. Amtrol, Inc.
- b. Armstrong Pumps, Inc.
- c. Bell & Gossett ITT; Fluid Handling Div.
- d. Taco, Inc.
- e. Keckley

3. Air Vents:

- a. Armstrong Machine Works.
- b. Bell & Gossett ITT; Fluid Handling Div.
- c. Hoffman Specialty ITT; Fluid Handling Div.
- d. Spirax Sarco.
- e. Amtrol, Inc.

4. Air Separators:

- a. Amtrol, Inc.
- b. Armstrong Pumps, Inc.
- c. Bell & Gossett ITT; Fluid Handling Div.
- d. Taco, Inc.
- e. The John Wood Co.

5. Diaphragm-Type Compression Tanks:

- a. Amtrol, Inc.
- b. Armstrong Pumps, Inc.
- c. Bell and Gossett ITT; Fluid Handling Div.
- d. Taco, Inc.
- e. The John Wood Co.
- f. Wessles

6. Pump Suction Diffusers:

- a. Amtrol, Inc.
- b. Armstrong Pumps, Inc.
- c. Bell & Gossett ITT; Fluid Handling Div.
- d. Taco, Inc.
- e. Victaulic Company of America

7. Automatic Flow Control Valves:
 - a. Griswold

8. Hydronic System Safety Relief Valves:
 - a. Kunkle Valve Co., Inc.
 - b. Lunkenheimer Co.
 - c. Watts Regulator Co.
 - d. Lonergan
 - e. Keckley
 - f. Bell & Gossett ITT; Fluid Handling Div.
 - g. Conbraco

9. Pressure Regulating Valves:
 - a. A.W. Cash Valve Mfgr. Corp.
 - b. Armstrong Machine Works, A-Y Division
 - c. Fisher Controls International, Inc.
 - d. Hoffman Specialty ITT; Fluid Handling Div.
 - e. Leslie Co.
 - f. Spirax Sarco
 - g. Spence Engineering Co., Inc.
 - h. Wilkins Regulator/Div Zurn Industries Inc.
 - i. Watts Regulator Co.

10. Pipe Escutcheons:
 - a. Chicago Specialty Mfg. Co.
 - b. Producers Specialty & Mfg. Corp.
 - c. Sanitary-Dash Mfg. Co.

11. Low Pressure Strainers:
 - a. Armstrong Machine Works.
 - b. Hoffman Specialty ITT; Fluid Handling Div.
 - c. Metraflex Co.
 - d. R-P&C Valve; Div. White Consolidated Industries, Inc.
 - e. Spirax Sarco.
 - f. Trane Co.
 - g. Victaulic Co. of America.
 - h. Watts Regulator Co.

12. Basket Strainers:
 - a. R-P&C Valve
 - b. Keckley

13. Dielectric Waterways
 - a. Victaulic Co.
 - b. Perfection Corp.
 - c. Flow Design Inc.
 - d. Perfection Corp.
 - e. Rockford-Eclipse Div.

14. Mechanical Sleeve Seal:

- a. Thunderline Corp.
- b. Metra Flex.

2.2 HYDRONIC PIPING SPECIALTIES:

- A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- B. Hydronic System Safety Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure to suit system and have the capability for field adjustment. Safety relief valve shall be designed, manufactured, tested and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250 degrees F maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Set valve to relieve at 10 psi above operating pressure.
- C. Pressure Reducing Valves: Diaphragm operated, bronze or brass body valve, with low inlet pressure check valve, stainless steel inlet strainer removable without system shut-down, and stainless steel valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.
- D. Coin Operated Manual Air Vent: Bronze body and nonferrous internal parts; 150 psig working pressure, 212 degrees F operating temperature; manually coin operated and having discharge outlet connection and 1/8 inch NPT male connection.
- E. Manual Air Vent: Provide ball valves as specified in Part 3.
- F. Automatic Air Vent: 100 psi working pressure, 240 degrees working temperature, stamped brass body and non-metallic float, with threaded outlet connector for "safe waste" discharge pipe.
 - 1. Amtrol 703 or approved equivalent.
- G. Air Separators: Welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and 350 degrees F operating temperature; perforated stainless steel air collector tube; tangential inlet and outlet connections; screwed connections up to and including 3 inch NPS; flanged connections for 4 inch NPS and above; threaded blowdown connection; sized as indicated for full system flow capacity.
- H. Diaphragm-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 240 degrees F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a flexible heavy duty diaphragm securely sealed into tank. Diaphragm shall be permanently sealed for tank sizes up to 45 gallon acceptance volume. For acceptance volumes greater than 45 gallons, tank shall have replaceable diaphragm/bladder. Diaphragm/bladder shall be

suitable for glycol service and system water treatment chemicals. Provide taps for pressure gauge and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1.

- I. Pump Suction Diffusers: Cast-iron body, with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger; 175 psig working pressure, 300 degrees F maximum operating temperature; and complete with the following features:
 - 1. Inlet vanes with length 1-1/2 times pump suction diameter or greater.
 - 2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
 - 3. Disposable fine mesh strainer to fit over cylinder strainer.
 - 4. Permanent magnet, located in flow stream, removable for cleaning.
 - 5. Adjustable foot support, designed to carry weight of suction piping.
 - 6. Blowdown tapping in bottom; gauge tapping in side.

- J. Automatic Flow Control Valves: Class 150, cast iron housing, stainless steel operating parts; threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger. Factory set to automatically control flow rates within plus or minus 5 percent design, while compensating for system operating pressure differential. Provide quick disconnect valves for flow measuring equipment. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and rate flow in GPM.

2.3 PIPE ESCUTCHEONS:

- A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

- B. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.4 LOW PRESSURE PIPELINE STRAINERS:

- A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screen. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inches and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inches and larger steam strainers.

- B. Threaded Ends, 2 inch and Smaller: Bronze or Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

- C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

- D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

- E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
- F. Grooved Ends, 2-1/2 inches and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

2.5 BASKET STRAINERS:

- A. For 50 psig systems or less (thru 12 inches): High-Tensile ASTM A126 Class B cast iron, angle design, ductile iron clamped cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045 inch perforations for through 3 inch diameter piping; .125 inch for 4 inch and larger.

R-P&C 528-C12, Class 125

- B. For 125 psig systems or less (thru 12 inch): High-Tensile ASTM A126, Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045" perforations for through 3 inch diameter piping; .125 inch for 4 inch and larger.

R-P&C 528-V12, Class 125

2.6 DIELECTRIC WATERWAY:

- A. General: Zinc electroplated nipple with non metallic lining for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion. Union style not acceptable.

2.7 MECHANICAL SLEEVE SEALS:

- A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation, as manufactured by Link-Seal or equal.

- B. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

- 1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

2.8 FABRICATED PIPING SPECIALTIES:

- A. Drip Pans: Provide drip pans fabricated from corrosion- resistant sheet metal with watertight joints, and with edges turned up 2-1/2 inches. Reinforce top, either by structural angles or by rolling top over ¼ inch steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1 inch drain line connection.

- B. Pipe Sleeves: Provide pipe sleeves of one of the following:

- 1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following

gauges: 3 inches and smaller, 20 gauge; 4 inches to 6 inches 16 gauge; over 6 inch, 14 gauge.

2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs. Provide fully welded waterstop/anchor ring fabricated from minimum 1/8 plate, extending minimum 1 inch from O.D. of sleeve, where noted in Part 3.
3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.
4. Sleeves for use with firestopping shall be fabricated in accordance with the installation instructions of the firestopping system.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES:

- A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.
- B. Strainers: Install strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff full port ball valve with 3/4 inch hose end and cap in strainer blow down connection. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.
 1. Provide strainers in supply line ahead of the following equipment, and elsewhere as indicated.
 - a. Pumps
 - b. Pressure reducing valves
 - c. Temperature or pressure regulating valves
 - d. Control valves
- C. Dielectric Waterway: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.
- D. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

3.2 HYDRONIC SPECIALTIES INSTALLATION:

- A. Manual Air Vent: Provide manual air vents at all high points and drops in the direction of flow, of all mains and risers of the hydronic systems, at heat transfer coils, radiation and elsewhere shown and as required for system air venting.
 1. Provide enlarged air collection standpipe where large air quantities can accumulate.
 2. Use a 1/2 inch ball valve with a soft copper tubing discharge pipe directed to a convenient collection point except as noted below.
 3. Use a coin operated air vent inside terminal unit and baseboard radiation enclosures.

- B. Provide automatic air vents where shown on drawings. Provide high capacity automatic air vents at all air separators, provide an isolation valve to allow removal of all automatic air vents, provide minimum 1/4 inch soft copper tubing to a convenient drain location, and to avoid water damage.
- C. Air Separator: Install inline air separators in hydronic systems pump suction lines. Install drain valve on units 2 inch and larger.
- D. Pump Suction Diffuser: Install pump suction diffusers on hydronic systems pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection. Arrange installation to allow strainer removal and replacement.
- E. Diaphragm-Type Compression Tank: Install diaphragm-type compression tanks in hydronic systems on floor stand as indicated. Provide Schraeder valve on air charge fitting. Vent and purge air from the water side, and charge tank with proper air charge to suit system design requirements.
 - 1. Provide support from the floor or structure adequate to carry twice the weight of the tank, piping connections, fittings, and weight of water assuming a full tank of water. Do not overload building components and structural members.

3.3 INSTALLATION OF FABRICATED PIPING SPECIALTIES:

- A. Drip Pans: Locate drip pans under piping as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.
- B. Pipe Sleeves: In fire resistive construction, coordinate the use of sleeves with the firestopping system requirements. See Section 15050. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect/Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves where noted below. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.
 - 1. Interior gypsum board, plaster, and masonry partitions: Install sheet metal sleeves.
 - 2. Interior cast in place concrete walls: Install steel pipe sleeves.
 - 3. Interior cast in place floors: Install steel pipe sleeves with water stop/anchor ring.
 - 4. Below ground and exterior cast-in-place concrete or masonry: Install steel pipe sleeves with waterstop/anchor ring.
 - 5. For core drilled solid concrete or precast concrete with blockouts, no sleeve is required, except provide sheet metal "collar" fastened and caulked to floors required to have extended sleeves.
- C. See Section 15241 for acoustical sleeve requirements.

END OF SECTION 15120

SECTION 15125 - PIPE EXPANSION JOINTS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of expansion compensation products of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. EJMA Compliance: Construct expansion compensation products in accordance with standards of the Expansion Joint Manufacturer's Association (EJMA).

1.2 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of expansion compensation product. Submit expansion compensation schedule showing Manufacturer's figure number, size, location, and features for each required expansion compensation product.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components.
- C. Shop Drawings: Submit shop drawings for fabricated expansion loops indicating location, dimensions, pipe sizes, and location and method of attachment of anchors.
- D. Maintenance Data: Submit maintenance data and spare parts lists for each type of expansion compensation product. Include this data, product data, and shop drawings in Maintenance Manual; in accordance with requirements of Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Packless Expansion Joints Compensators:
 - a. Flexonics Div.; UOP, Inc.
 - b. Hyspan Precision Products, Inc.
 - c. Keflex, Inc.
 - d. Metraflex Co.
 - e. American BOA, Inc.
 - 2. Packless Rubber Expansion Joints:
 - a. Garlock; Mechanical Packing Div.
 - b. Mason Industries, Inc.
 - c. Metraflex Co.

3. Pipe Alignment Guides:
 - a. Hyspan Precision Products, Inc.
 - b. Metraflex Co.
 - c. Keflex, Inc.
 4. Slip Joints
 - a. Advanced Thermal Systems, Inc.
 - b. Hyspan Precision Products, Inc.
 5. Flexible Ball Pipe Joints
 - a. Advanced Thermal Systems, Inc.
 - b. Barco Div., Marison Industries
 - c. Gustin-Bacon Div.; Aeroquip Corp.
 6. Grooved Piping Couplings and Nipples Expansion Joints:
 - a. Gustin-Bacon Div.; Aeroquip Corp.
 - b. ITT Grinnell
 - c. Victaulic Co. of America
- 2.2 PIPE EXPANSION JOINTS, GENERAL:
- A. Pipe expansion joints shall provide 200 percent absorption capacity of calculated piping expansion between anchors.
- 2.3 PACKLESS EXPANSION JOINTS:
- A. General: Provide bellows expansion joints where indicated for piping systems, with materials and pressure/temperature ratings selected by manufacturer to suit intended service. Select expansion joints to provide 200 percent absorption capacity with 30 percent safety factor.
 - B. Bellows-Type Expansion Joints:
 1. Externally pressurized, bellows-type:
 - a. ASTM A240 T304 Stainless Steel laminated bellows.
 - b. Flanged Connections, conforming to ANSI B16.5.
 - c. Lifting lug.
 - d. Drain port.
 - e. 150 psig design pressure.
 - f. Minimal warranted cycle life of 10,000 full-stroke cycles.
 - g. Internally guided.
 2. Bellows-type expansion joint:
 - a. ASTM A240 T304 Stainless Steel laminated bellows.
 - b. Flanged connections, conforming to ANSI B16.5.
 - c. 150 psig design pressure.
 - d. Internal stainless steel liner.
 - e. Shouldered support of bellows to minimize stress at pipe-bellows weld.
 - f. External shroud
 - g. Minimum warranted life of 10,000 full-stroke cycles.

- C. Expansion Compensators: Pressure rated for 125 psi for low-pressure systems and for 175 psi for high-pressure systems with a cycle life of 10,000 full-stroke cycles. Units shall have 2-ply phosphor bronze bellows, brass shrouds, and end fittings for copper piping systems and 2-ply stainless steel bellows, carbon steel shrouds, and end fittings for steel piping systems. Expansion compensators shall have internal guides and anti-torque device and removable end clip for proper positioning.
 - 1. Provide Keflex series 7Q; or equal.
 - D. Rubber Expansion Joints: Fabric-reinforced butyl rubber with full- faced integral flanges, external control rods and shall be internally reinforced with steel retaining rings over entire surface of flanges, drilled to match flange bolt holes.
- 2.4 SLIP JOINTS:
- A. Slip Joints: Carbon steel slip type, designed for repacking under pressure. Slip joints shall have drip connections for steam piping systems and flanged or weld ends to mate with piping system. Packing shall be an asbestos-free compound.
- 2.5 FLEXIBLE BALL PIPE JOINTS:
- A. Joints shall be designed for 360 degree rotation and with minimum of 30 degree angular deflection for sizes 6 inches and smaller; 15 degree for sizes 8 inches and larger.
 - B. Joints shall be carbon steel and shall comply with Section II of ASME Boiler and Pressure Vessel Code and ASME B31.9 "Building Service Piping" for materials and design of pressure containing parts and bolting. Packing shall be asbestos-free composition.
 - 1. Each assembly shall be factory tested with steam at working pressure of piping system for zero leaks before shipment.
- 2.6 EXPANSION JOINTS FOR GROOVED PIPING:
- A. Combination Couplings and Nipples: Cut grooved short ASTM A 53 steel pipe nipples and ductile iron or malleable iron couplings, with removable ties to hold joint compressed or expanded during piping fabrication. Select suitable gasket materials for piping system.
 - B. Slip-Type Expansion Joints: Ductile iron or malleable iron housing, ASTM A 53 steel pipe body, and polytetrafluoroethylene (PTFE) modified polyphenylene coated steel pipe slide. Select suitable gasket material for piping system.
- 2.7 PIPE ALIGNMENT GUIDES:
- A. General: Provide pipe alignment guides at locations and spacing indicated. Construct with 4-finger spider traveling inside guiding sleeve, with provision for anchoring to concrete substrate.
 - 1. Grinnell Fig. 256
 - 2. Guides shall be equipped with factory insulation insert, thickness to match adjoining insulation. Insulation shall be Hydrous Calcium Silicate, 1200 F. maximum temperature, with 0.31 K-factor and vapor barrier.

PART 3 EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which expansion compensation products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer. Coordinate anchor locations & loads with Structural Engineer.

3.2 EXPANSION JOINTS:

- A. Install expansion joints where indicated, for adequate expansion of installed piping system. Install in accordance with manufacturer's instructions. Provide pipe anchors and pipe alignment guides as indicated, and in accordance with manufacturer's recommendations. Align units properly to avoid end loading and torsional stress.

3.3 EXPANSION LOOPS:

- A. Fabricate expansion loops to dimensions indicated, in locations indicated, for adequate expansion compensation of installed piping system. Provide pipe anchors and pipe alignment guides as indicated, to properly anchor and align piping in relationship to expansion loops.

3.4 EXPANSION COMPENSATION FOR RISERS AND TERMINALS:

- A. Install connection between piping mains and risers with at least 5 pipe fittings including tee in main. Install connections between piping risers and terminal units with at least 4 pipe fittings including tee in riser.

3.5 INSTALLATION OF PIPE ALIGNMENT GUIDES:

- A. Install pipe alignment guides on piping that adjoins expansion joints and elsewhere as indicated.
- B. Anchor to building substrate.

END OF SECTION 15125

SECTION 15135 - METERS AND GAUGES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-15 sections.
- B. Types of meters and gauges specified in this section include the following:
 - 1. Temperature Gauges and Fittings:
 - a. Glass Thermometers.
 - b. Remote Reading Dial Thermometers.
 - c. Dial Type Insertion Thermometers.
 - d. Photo Voltaic Digital Thermometers
 - e. Thermometer Wells.
 - f. Temperature Gauge Connector Plugs.
 - 2. Pressure Gauges and Fittings:
 - a. Pressure Gauges.
 - b. Pressure Gauge Cocks.
 - c. Pressure Gauge Connector Plugs.
 - 3. Flow Measuring Meters:
 - a. Venturi Tube Flow Measuring Elements.
 - b. Calibrated Balance Valves.
 - c. Portable Flow Meter Read-out Kits.
- C. Meters and gauges furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-15 sections.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of meters and gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.
 - 2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.
- C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.
- B. All flow measuring devices to be provided shall be reviewed and approved by the test & balance contractor and the temperature control contractor for proper scale, rangeability and function prior to submitting shop drawings. The test & balance contractor and temperature control contractor shall provide a typed letter stating this review has been completed and included with shop drawing submittals.
- C. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Glass Thermometers:
 - a. Ernst Gauge Co.
 - b. Marshalltown Instruments, Inc.
 - c. Terice (H.O.) Co.
 - d. Weiss Instruments, Inc.
 - 2. Remote Reading Dial Thermometers:
 - a. Ametek/U.S. Gauge.
 - b. Marsh Instrument Co.; Unit of General Signal.
 - c. Terice (H.O.) Co.
 - d. Weiss Instruments, Inc.
 - e. Versa Gauge
 - 3. Photo Voltaic Digital Thermometers:
 - a. Versa Gauge
 - b. Weiss Instruments
 - 4. Dial Type Insertion Thermometers and Wells:
 - a. Marsh Instrument Co.; Unit of General Signal.
 - b. Taylor Instrument Co.
 - c. Terice (H.O.) Co.
 - d. Weiss Instruments, Inc.
 - 5. Temperature Gauge Connector Plugs:
 - a. Fairfax Company
 - b. Peterson Equipment Co.

- c. Universal Lancaster
 - d. Sisco
 - e. MG Piping Products Co.
6. Pressure Gauges:
- a. Ametek/U.S. Gauge.
 - b. Marsh Instrument Co.; Unit of General Signal.
 - c. Marshalltown Instruments, Inc.
 - d. Terice (H.O.) Co.
 - e. Weiss Instruments, Inc.
 - f. MG Piping Products Co.
 - g. Versa Gauge
7. Pressure Gauge Connector Plugs:
- a. Fairfax Company
 - b. Peterson Equipment Co.
 - c. Universal Lancaster
 - d. Sisco
 - e. MG Piping Products Co.
8. Venturi Tube Flow Measuring Elements:
- a. Gerand
 - b. Barco/Aeroquip Corp.
 - c. Presso
 - d. Flow Design Inc.
9. Calibrated Balancing Valves:
- a. Armstrong+
 - b. "Flowset" - Flow Design, Inc.
 - c. Presso.
 - d. Tour and Anderson, Inc.
 - e. Gerand "Balvalve Indicator"
 - f. Bell and Gossett (To Match Existing Only)
- 2.2 GLASS THERMOMETERS:
- A. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
 - B. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9 inches long.
 - C. Adjustable Joint: Die cast aluminum, finished to match case, 180 degrees adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device.
 - D. Tube and Capillary: Mercury filled, magnifying lens, 1 percent scale range accuracy, shock mounted.
 - E. Scale: Satin faced, non-reflective aluminum, permanently etched markings.

- F. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation. Sampling tube type with duct flange for air duct installations.
- G. Range: Conform to the following:
 - 1. Hot Water: 30 degrees - 240 degrees F with 2 degrees F scale divisions (0 degrees - 160 degrees C) with 2 degrees C scale divisions).
 - 2. Chilled Water: 0 - 100 degrees F with 2 degrees F scale divisions (0 degrees - 100 degrees C with 1 degrees C scale divisions).
 - 3. Steam and Condensate: 50–400 degrees F with 2 degrees scale divisions (10-205 degrees C with 1 degrees scale divisions).
 - 4. Duct work: 0-160 degrees F with 2 degrees scale divisions.

2.3 PHOTO VOLTAIC DIGITAL THERMOMETERS:

- A. Case: High image ABS, with photovoltaic power cell and digital readout.
- B. Range: Selectable between -40-300 degrees F/ -40-150 degrees F, displayed to 0.1 degrees.
- C. Accuracy: 1 percent of reading or 1 degrees F, whichever is greater. Recalibratable via internal potentiometer. Not affected by ambient temperature.
- D. Ambient light required: 10 lux.
- E. Display update: 10 seconds.
- F. Stem: Compatibly with standard thermowell for piping applications, or sampling tube with flange for air duct applications.

2.4 REMOTE READING DIAL THERMOMETERS:

- A. General: Provide remote reading dial thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
- B. Type: Vapor tension.
- C. Case: Drawn steel or brass, glass lens, 4-1/2 inch diameter.
- D. Movement: Brass, precision geared.
- E. Tubing: Bronze double braided armor over copper capillary, length to suit installation.
- F. Bulb: Copper with separable socket for liquids, averaging element for air.
- G. Accuracy: + or - one scale division.
- H. Range: Conform to the following:
 - 1. Hot Water: 30 degree - 240 degree F (0 degree - 115 degree C).
 - 2. Chilled Water: 30 degree - 180 degree F (0 degree - 85 degree C).
 - 3. Air: 30 degree - 180 degree F (0 degree - 85 degree C).

2.5 DIAL TYPE INSERTION THERMOMETERS:

- A. General: Provide dial type insertion thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
- B. Type: Bi-metal, stainless steel case and stem, 1 inch diameter dial, dust and leak proof, 1/8 inch diameter stem with nominal length of 5 inch.
- C. Accuracy: 0.5 percent of dial range.

- D. Range: Conform to the following:
 - 1. Hot Water: 0 degrees - 220 degrees F (-10 degrees - 110 degrees C).
 - 2. Chilled Water: 25 degrees - 125 degrees (-10 degrees - 110 degrees C).

- 2.6 THERMOMETER WELLS:
 - A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2 inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

- 2.7 TEMPERATURE GAUGE CONNECTOR PLUGS:
 - A. General: Provide temperature gauge connector plugs pressure rated for 500 psi and 200 degrees F (93 degrees C). Construct of brass and finish in nickel-plate, equip with 1/2inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

- 2.8 PRESSURE GAUGES:
 - A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
 - B. Type: General use, 1 percent accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.
 - C. Case: Drawn steel or brass, glass lens, 4-1/2inch diameter.
 - D. Connector: Brass with 1/4inch male NPT. Provide protective syphon when used for steam service.
 - E. Scale: White coated aluminum, with permanently etched markings.
 - F. Range: Conform to the following:
 - 1. Vacuum: 30 inches Hg - 15 psi.
 - 2. Water: 0 - 100 psi.

- 2.9 PRESSURE GAUGE COCKS:
 - A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Gauge cock shall be 1/4 inch female NPT on each end ball valve as specified in Section 15100 - Valves.
 - B. Syphon: 1/4 inch straight coil constructed of brass tubing with 1/4 inch male NPT on each end.
 - C. Snubber: 1/4 inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

- 2.10 VENTURI TUBE FLOW MEASURING ELEMENTS:
 - A. Primary flow measuring elements shall consist of venturi tubes. Arrange piping in accordance with manufacturer's published literature. In horizontal pipes, place connections slightly above horizontal centerline of pipe.

- B. Provide each primary element with integral tab, or metal tag on stainless steel wire, extending outside pipe covering on which is stamped or clearly printed in plainly visible position the following information:
 - 1. Manufacturer's name and address.
 - 2. Serial number of meter to which element is to be connected.
 - 3. Name, number, or location of equipment served.
 - 4. Specified rate of flow.
 - 5. Multiplier (including unity, where applicable) to be applied to meter reading.
 - C. Provide taps with Schraeder or Hanson type fittings. Provide tap extensions to accommodate insulation.
 - D. Manufacturer shall certify venturi tubes for actual piping configuration. Any necessary piping changes required for certification shall be provided without cost to Owner. Insert type tubes may be furnished, provided they meet specification requirements in other respects.
 - E. Provide venturi with throat diameter such that specified rate of flow will register scale reading of between 20 percent and 80 percent of full scale value.
 - F. Venturi sizes and beta ratios shall be selected so that design flow rates shall read between 20 percent and the full scale range on a linear meter (e.g. between 10 inches and 50 inches on a 0-50 inches meter), with permanent pressure loss of not more than 25 percent of indicated flow rate differential pressure.
 - G. Provide venturi tubes of solid brass or bronze. Tubes larger than 2 inches shall have flanges or butt weld connections and may be cast iron or steel. Steel tubes may be fabricated or cast with cadmium or zinc-plating. Line throats of cast iron tubes with bronze and plate cast iron portion with cadmium.
 - H. Tubes shall be calibrated and tested by independent testing laboratory and performance data furnished with shop drawings.
 - I. Connections for attachment to portable flow meter hoses shall be readily accessible.
- 2.11 CALIBRATED BALANCE VALVES:
- A. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout port with a quick connect valve designed to minimize system fluid loss during monitoring process. Provide balance valves with preformed insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.
 - B. Design, variable orifice type:
 - 1. Globe-type valve.
 - 2. Multiple turns of handwheel from full closed to full open.
 - 3. Bubble-tight shut-off.
 - 4. Schraeder type taps upstream and downstream.
 - 5. Memory stop device to allow valve to be returned to balanced position after being closed.
 - 6. Provide slide rule type flow calculator, include in Operation and Maintenance Manual.
 - C. Design, valve and venturi type:

1. Ball or butterfly type valve.
2. Bubble-tight shut-off.
3. Fixed venturi, upstream of valve.
4. Schraeder type taps on venturi, upstream and downstream.
5. Memory stop device to allow valve to be returned to balanced position after being closed.
6. Provide metal tag with flow curve for each valve.

PART 3 EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF THERMOMETERS:

- A. General: Install thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.
- B. Application of Thermometers:
 1. Use glass thermometers in the following locations:
 - a.
 - b.
 - c.
 2. Use photo voltaic thermometers in the following locations:
 - a.
 - b.
 - c.
- C. Locations: Install in the following locations, and elsewhere as indicated:
 1. At inlet and outlet of each hydronic zone.
 2. At inlet and outlet of each hydronic boiler and chiller.
 3. At inlet and outlet of each hydronic coil in air handling units.
 4. At inlet and outlet of each hydronic heat exchanger.
 5. In discharge duct or plenum of air handling units and built-up central systems.
- D. Remote Reading Dial Thermometers: Install on control panels as indicated. Run tubing between panel and thermometer bulb, adequately supported to prevent kinks. Select tubing length so as to not require coiling of tubing.
- E. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.
- F. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable temperature gauge for each plug connection.

3.3 INSTALLATION OF PRESSURE GAUGES:

- A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
 - B. Locations: Install in the following locations, and elsewhere as indicated:
 - 1. At suction and discharge of each pump.
 - 2. At discharge of each pressure reducing valve.
 - 3. At water service outlet.
 - 4. At inlet and outlet of water cooled condensers and refrigerant cooled chillers.
 - C. Pressure Gauge Cocks: Install in piping tee with snubber. Install syphon for steam pressure gauges.
 - D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable pressure gauge for each plug connection.
- 3.4 INSTALLATION OF FLOW MEASURING METERS:
- A. General: Install flow measuring meters on piping systems located in accessible locations at most readable position.
 - B. Locations: Install in the following locations, and elsewhere as indicated.
 - 1. At discharge of each pump.
 - 2. At inlet of each hydronic coil.
 - C. Wafer-Type Flow Meters: Install between 2 Class 125 pipe flanges, ANSI B16.1 (cast-iron) or ANSI B16.24 (cast- bronze). Provide minimum straight lengths of pipe upstream and downstream from meter in accordance with manufacturer's installation instructions.
 - D. Calibrated Balance Valves: Install on piping with readout valves in vertical upright position. Maintain minimum length of straight unrestricted piping equivalent to 3 pipe diameters upstream of valve.
- 3.5 ADJUSTING AND CLEANING:
- A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.
 - B. Cleaning: Clean windows of meters and gauges and factory- finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 15135

SECTION 15140 - SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.
 - 2. NFPA Compliance: Hangers and supports shall comply with NFPA standard No. 13 when used as a component of a fire protection system.
 - 3. UL and FM Compliance: Hangers, supports, and components shall be listed and labeled by UL and FM where used for fire protection piping systems.

OR

Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Hangers, supports, and components shall be listed and labeled by a NRTL where used for fire protection piping systems. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

- 4. Duct Hangers: SMACNA Duct Manuals
 - 5. MSS Standard Compliance:
 - a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-69.
- 1.2 SUBMITTALS:
- A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.
 - B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.
 - C. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.
 - D. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Pipe Hangers and Supports:

- a. B-Line Systems Inc.
- b. ANVIL International
- c. PHD Manufacturing, Inc.
- d. Unistrut Metal Framing Systems
- e. Hubbard Enterprises (Supports for domestic water piping)
- f. Specialty Products Co. (Supports for domestic water piping).

2. Saddles, Shield and Thermal Shield Inserts:

- a. ANVIL International
- b. Pipe Shields, Inc.
- c. B-Line
- d. Insulated Saddle Shield Insert Product Inc.

3. Roof Equipment Supports:

- a. Custom Curb, Inc.
- b. Pate Co.
- c. Thycurb Div.; Thybar Corp.
- d. Vent Products, Inc.

4. Concrete Inserts and Anchors:

- a. Unistrut Metal Framing Systems
- b. Power-Strut
- c. ITW Ramset/Red Head
- d. Hilti
- e. B-Line

2.2 PIPE HANGERS & SUPPORTS:

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-69.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.
2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Adjustable Clevis Hanger: MSS Type.

1. Steel Pipe, size 3/8" thru 30", Type 1.
2. Non-insulated Copper Pipe, size 1/2" thru 4", Type 1. (PVC Coated)

3. Cast Iron Pipe, size 4" thru 24", Type 1.
- C. Adjustable Swivel Ring for Non-insulated Pipe: MSS Type .
 1. Steel Pipe, size 1/2" thru 8", Type 7.
 2. Copper Pipe, size 1/2" thru 4", Type 7 (PVC Coated)
- D. Pipe Clamps: MSS Type .
 1. Steel Pipe, size 3/4" thru 24", Type 8.
 2. Copper Pipe, size 1/2" thru 4", Type 8 (PVC Coated).
- E. U Bolts: MSS Type .
 1. Steel Pipe, size 1/2" thru 30" Type 24
 2. Copper Pipe, size 1/2" thru 8", Type 24 (PVC Coated).
- F. Straps: MSS Type 26.
- G. Pipe Stanchion Saddle: MSS Type 37.
- H. Yoke & Roller Hanger: MSS Type 43
- I. Hanger Rods: Continuous threaded steel, sizes as specified.
- J. Hangers:
 1. Hot Pipes:
 - a. 1/2" through 1-1/2": Adjustable wrought steel ring.
 - b. 2" through 5": Adjustable wrought steel clevis.
 - c. 6" and Over: Adjustable steel yoke and cast iron roll.
 2. Cold Pipes:
 - a. 1/2" through 1-1/2": Adjustable wrought steel ring.
 - b. 2" and Over: Adjustable wrought steel clevis.
 3. Multiple or Trapeze: Structural steel channel (with web vertical and engineered for the specific applications), with welded spacers and hanger rods. Provide cast iron roll and base plate for hot pipe sizes six inches and over. Provide hanger rods one size larger than for largest pipe in trapeze. If the deflection at center of trapeze exceeds 1/360 of the distance between the end hangers, install an additional hanger at mid-span or use a larger channel.
- K. Wall Supports for Horizontal Steel Pipe:
 1. 1/2 inch through 4inches: Offset or straight j-hook.
 2. 4 inches and Over: Welded steel bracket Type 31, 32 or 33 and wrought steel clamp. Provide adjustable steel yoke and cast iron roll Type 44 for hot pipe 200° F and over and for sizes six inches and over.
- L. Supports for Vertical Pipe: Steel riser clamp. Type 8.

M. Upper Attachments:

1. For attaching hanger rods to structural steel I-beams:
 - a. Provide adjustable beam clamp, MSS-Type 21. Attach to bottom flange of beam.
2. For attaching hanger rods to bar joists:
 - a. When bottom chord is constructed of structural steel angles, provide square washer. Place hanger rod between backs of the two angles and support with the washer and dual locking nuts on top of the angles. Spot weld washer to angles.
 - b. When bottom chord is constructed of round bars, provide Elcen No. 137 bar joint washer or equal.

2.3 CONCRETE INSERTS AND ANCHORS:

- A. Inserts: Case shall be of galvanized carbon steel with square threaded concrete insert nut for hanger rod connection; top lugs for reinforcing rods, nail holes for attaching to forms. This type of upper attachment is to be used for all areas having poured in place concrete construction.
 1. Size inserts to suit threaded hanger rods.
- B. Provide fasteners attached to concrete ceilings that are vibration and shock resistant. Provide hangers for piping attached to concrete construction with one of the following types.
 1. Concrete insert per MSS SP 69, Type 18.
 2. Powder driven fasteners subject to approval of Architect and Structural Engineer. Each fastener shall be capable of holding a test load of 1000 pounds whereas the actual load shall not exceed 50 pounds.
 3. Self-drilling expansion shields. The load applied shall not exceed one-fourth the proof test load required.
 4. Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.
- C. Anchors: Carbon steel, zinc plated and coated with a clear chromate finish. Installation shall be in holes drilled with carbide-tipped drill bits or by use of self-drilling anchors.
 1. Provide anchors suitable for the location of installation and designed to withstand all forces and movements acting in the anchor. Manufacture pipe anchors in accordance with MSS SP 69. Provide a safety factor of four for the anchor installation.

2.4 SADDLES AND THERMAL SHIELD INSERTS:

- A. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
- B. Protection Shields: MSS Type 40; 180 degrees arc, galvanized steel, minimum 12 inches long, to prevent crushing of insulation.

- C. Thermal Shield Inserts: Provide 100-psi minimum compressive strength, waterproof, asbestos free calcium silicate, encased with a sheet metal enclosure. Insert and shield shall cover the entire circumference or the bottom half circumference of the pipe as required by Part 3 of this Specification, and shall be of length recommended by the manufacturer for pipe size and thickness of insulation. For cold piping, calcium silicate shall extend beyond the sheet metal shield to allow overlap of the vapor barrier. Where piping 4 inches and larger is supported on trapeze or pipe rollers, provide double thickness shields. For piping 12 inches and over, provide 600 psi calcium silicate structural insert.

2.5 SPRING HANGERS AND SUPPORTS:

- A. General: Provide factory-fabricated spring hangers and supports complying with MSS SP-69, of one of the following MSS types listed, selected by Installer to suit piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select spring hangers and supports to suit pipe size and loading.
- B. Restraint Control Devices: MSS Type 47.
- C. Spring Cushion Hangers: MSS Type 48.
- D. Spring Cushion Roll Hangers: MSS Type 49.
- E. Spring Sway Braces: MSS Type 49.
- F. Variable Spring Hangers: MSS Type 51; preset to indicated load and limit variability factor to 25 percent.
- G. Variable Spring Base Supports: MSS Type 52; preset to indicated load and limit variability factor to 25 percent; include load flange.
- H. Variable Spring Trapeze Hangers: MSS Type 53; preset to indicated load and limit variability factor to 25 percent.
- I. Constant Supports: Provide one of the following types, selected to suit piping system. Include auxiliary stops for erection and hydrostatic test, and field load-adjustment capability.
 - 1. Horizontal Type: MSS Type 54.
 - 2. Vertical Type: MSS Type 55.
 - 3. Trapeze Type: MSS Type 56.

2.6 MISCELLANEOUS MATERIALS:

- A. Steel Plates, Shapes, and Bars: ASTM A 36.
- B. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
- C. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
- D. Pipe Alignment Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any),

and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

2.7 ROOF EQUIPMENT SUPPORTS:

- A. [See details on drawings](#)

PART 3 1 EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION:

- A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments. Review Structural Drawings to obtain structural support limitations.
- B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at [project site / Engineer's office](#) with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified. Provide Shop Drawing showing method and support locations from structure.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:

- A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.
- B. New Construction:
1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.
 2. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4 inches or ducts over 60 inches wide.
 3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
 4. Where inserts are omitted drill through concrete slab from below and provide rod with recessed square steel plate and nut above slab if construction above permits.
- C. Existing Construction:

1. In existing concrete construction, drill into concrete slab and insert and tighten expansion anchor bolt. Connect anchor bolt to hanger rod. Care must be taken in existing concrete construction not to sever reinforcement rods or tension wires.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:

- A. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
- B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories.
- C. Support fire-water piping independently from other piping systems.
- D. Prevent electrolysis and abrasion in support of copper tubing by use of hangers and supports which are plastic coated, or with EPDM isolation strips. Duct tape or copper coated hangers are not acceptable.
- E. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion joints, expansion loops, expansion bends and similar units and within 1'-0" of each horizontal elbow.
- F. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
- G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.
- H. Insulated Piping: Comply with the following installation requirements.
 1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.
 2. Saddles: Install Protection saddles where supported by pipe rollers. Fill interior voids with segments of insulation that match adjoining pipe insulation.
 3. Shields: Install galvanized steel protection shields, on all insulated piping 2 inches and less, except where required to be clamped. Where necessary to prevent dislocation, strap shield to pipe with wire ties or "Zip Strips".
 4. Thermal Inserts: Provide thermal shield inserts at all supports for all insulated piping over 2 inches and for all piping required to be clamped. Provide 180 percent inserts at clevis and roller hangers. Provide 360 percent inserts for all trapeze and clamped supports.

- I. Install horizontal hydronic piping with the following minimum rod sizes and maximum spacing:

SIZE (NPS)	MAX. SPAN IN FEET		MIN. ROD SIZE-INCHES
	Steel	Copper	
1	7	6	3/8
1-1/2	9	8	3/8
2	10	8	3/8
3	12	10	1/2
4	14	12	5/8
5	16	13	5/8
6	17	14	3/4

- J. Install steel natural gas piping with the following minimum rod size and maximum spacing:

SIZE (NPS)	MAX. SPAN IN FEET	MIN. ROD SIZE - INCHES
1/2	8	3/8
3/4 TO 1	9	3/8
1-1/2	12	3/8
2	13	3/8
3	15	1/2
4	17	5/8
5	19	5/8
6	21	3/4

Vertical, all sizes every floor level

- K. Support horizontal cast iron pipe as follows:

1. Hub & Spigot: All sizes.
 - a. 10 ft. max spacing: min of one (1) hanger per pipe section close to joint on the barrel. Also at change of direction and branch connections.
 - b. Support vertical cast iron pipe at each story height and at its base. Secure vertical hub and spigot pipe immediately below the hub.
 - c. Use hanger rods same size as for steel pipe.
2. .No-Hub: All sizes

- a. With Clamp-All and Anaheim Series 4000 stainless steel couplings and MG cast iron couplings: one hanger to each joint.
 - b. With all other stainless steel band type couplings: one hanger to each side of joint.
 - c. Support all horizontal cast iron pipe within 18 inches of each joint and with 5 feet maximum spacing between hangers, except that pipe exceeding 5 feet in length shall be supported at intervals no greater than 10 feet.
 - d. Use hanger rods same size as for steel pipe.
 - e. Support vertical cast iron pipe at each story height and at its base. Support vertical no-hub pipe so that the weight is carried from the pipe to the support and not from the joint to the support.
- L. Place a hanger within one foot of each horizontal elbow.
- M. Use hangers which are vertically adjustable 1-1/2 inch minimum after piping is erected.
- N. Support vertical steel and copper piping at every story height but at not more than 15 foot intervals for steel and 10 feet for copper.
- O. Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers.
- P. Where practical, support riser piping independently of connected horizontal piping.
- Q. Support steam supply and condensate return pipe runs on adjustable roller hangers.
- R. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.
- S. Securely anchor and support plumbing domestic water piping in chases or walls. Use factory manufactured clamps and brackets connected to fixture s, waste/vent piping or brackets connected to studs. Wires or straps will not be permitted.
1. When copper supplies are connected to flush valves, support the tubing by the studs or by a fixture, not by clamping to waste/vent piping.
 2. Prevent copper tubes from making contact with steel brackets using fire retardant polyethylene inserts or other dielectric insulating material. Duct tape shall not be used.
- T. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:
1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the Contractor shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.
 2. Powder-driven fasteners may be used only where they will be concealed after the construction is complete. Where an occasional fastener appears to be improperly installed, additional fastener(s) shall be driven nearby (not closer than 6 inches) in undisturbed concrete. Where it is considered that many fasteners are improperly

installed, the Contractor shall test load any 50 successively driven fasteners. If 10 percent or more of these fasteners fail, the Contractor shall utilize other fastening means as approved and at no additional cost to the Owner.

3. Hangers for piping and ducts shall be attached to cellular steel floor decks with steel plates and bolted rod conforming to the steel deck manufacturer's requirements. Where the individual hanger load exceeds the capacity of a single floor deck attachment, steel angles, beams or channels shall be provided to span the number of floor deck attachments required.
4. Welding may be used for securing hangers to steel structural members. Welded attachments shall be designed so that the fiber stress at any point of the weld or attachment will not exceed the fiber stress in the hanger rod.

3.5 INSTALLATION OF ANCHORS:

- A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31.9, and to prevent transfer of loading and stresses to connected equipment.
- B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31.9 and with AWS Standards D1.1.
- C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to control movement to compensators.
- D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping. Provide shop drawing for review by Engineer.

3.6 SHEET METAL DUCT HANGERS AND SUPPORTS:

- A. Provide in accordance with SMACNA HVAC duct construction standards.
- B. Additional Hanger Requirements:
 1. 2" to 24" from flexible connections of fans.
 2. 2" to 24" from the outlets or flexible connections of VAV control units or mixing boxes.
 3. 12" to 36" from the main duct to the first hanger of long branch ducts.
 4. 2" to 12" from the ends of all branch ducts and linear diffuser plenums.
 5. 2" to 24" from fire damper break-away joints.
 6. Hangers at throat and heel of round or square elbows 48" or greater in width.

3.7 EQUIPMENT SUPPORTS:

- A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.
- B. Grouting: Place grout under supports for piping and equipment.
- C. Concrete bases for the mechanical equipment indoors or outdoors will be provided by the General Contractor only if shown on the architectural or structural drawings. Otherwise, all bases shall be provided by this Contractor.

- D. Housekeeping bases shall be 4 inches thick minimum, extended 4 inches beyond machinery bedplates.
- E. This Contractor shall be responsible for the proper size and location of all bases and shall furnish all required anchor bolts and sleeves. If bases are provided by the General Contractor, furnish him with templates showing the bolt locations.
- F. Equipment shall be secured to the bases with anchor bolts of ample size. Bolts shall have bottom plates and pipe sleeves and shall be securely imbedded in the concrete. All machinery shall be grouted under the entire bearing surface. After grout has set, all wedges, shims and jack bolts shall be removed and the space filled with non-shrinking grout. This Contractor shall provide lead washers at all equipment anchor bolts.
- G. Construct equipment supports above floor of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.
- H. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment. See also Section 15241.

3.8 PREFABRICATED ROOFTOP EQUIPMENT SUPPORTS:

A. Equipment Bases:

- 1. Equipment base shall be solid top combination equipment base with integral duct curb and stepped cant to match roof insulation. Base shall pitch to match roof pitch and provide level unit installation.
- 2. Base shall be constructed of reinforced 18 gauge galvanized steel with all welded components, full mitered corners, factory installed 1-1/2 inches thick rigid fiberglass insulation, wood nailer, and galvanized steel counter- flashing. Base shall be shipped as one piece.

B. Equipment Rails:

- 1. Equipment rail shall be constructed of 18 gauge galvanized steel shell, base plate, and counterflashing with factory installed wood nailer, fully mitered end sections, stepped cant to match roof insulation. Rails shall pitch to match roof pitch and provide level installation.

C. All supports shall be installed in accordance with manufacturer's recommendations.

3.9 METAL FABRICATION:

- A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours at welded surfaces match adjacent contours.

3.10 ADJUSTING:

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.
 1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

OR

Touch-Up Painting: Cleaning and touch-up painting of field welds, bolted connections, and abraded areas of the shop paint on miscellaneous metal is specified in Division 9 section "Painting" of these specifications.

- C. For galvanized surfaces clean welds bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 15140

SECTION 15190 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.2 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any). Only tag valves which are intended for emergency shut-off and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut off valves. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
- B. Mechanical Identification:
 - 1. Allen Systems, Inc.
 - 2. Brady (W.H.) Co.; Signmark Div.
 - 3. Brimar Industries, Inc.
 - 4. Industrial Safety Supply Co., Inc.
 - 5. Seton Name Plate Corp.
 - 6. PVC Specialties

2.2 MECHANICAL IDENTIFICATION MATERIALS:

- A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-15 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS:

- A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping or to match existing size

in existing building, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.

- B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
- C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated comply with ANSI A13.1 for colors or to match existing building standard identification.

2.4 PLASTIC PIPE MARKERS:

- A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.
- B. Insulation: Furnish 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F. (52 degrees C.) or greater. Cut length to extend 2 inches beyond each end of plastic pipe marker.
- C. Small Pipes: For external diameters less than 6 inches (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
 - 1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
 - 2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch.
- D. Large Pipes: For external diameters of 6 inches and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
 - 1. Steel spring or non-metallic fasteners.
 - 2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2 inches wide; full circle at both ends of pipe marker, tape lapped 3 inches.
 - 3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.
- E. Lettering: Comply with piping system nomenclature as specified, scheduled, shown, or to match existing building lettering nomenclature system and abbreviate only as necessary for each application length.
- F. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.5 PLASTIC DUCT MARKERS:

- A. General: Provide manufacturer's standard laminated plastic, duct markers.
- B. For hazardous exhausts, use colors and designs recommended by ANSI A13.1.

- C. Nomenclature: Include the following:
 - 1. Direction of air flow.
 - 2. Duct service (supply, return, exhaust, etc.)
- 2.6 PLASTIC TAPE:
- A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
 - B. Width: Provide 1-1/2 inches wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inches, 2-1/2 inches wide tape for larger pipes.
 - C. Color: Comply with ANSI A13.1, except where another color selection is indicated.
- 2.7 UNDERGROUND-TYPE PLASTIC LINE MARKERS:
- A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6 inches wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.
 - B. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.
- 2.8 VALVE TAGS:
- A. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4 inch high letters and sequenced valve numbers 1/2 inch high, and with 5/32 inch hole for fastener.
 - 1. Provide 1-1/2 inch diameter tags, except as otherwise indicated.
 - 2. Fill tag engraving with black enamel.
- OR
- B. Plastic Laminate Valve Tags: Provide manufacturer's standard 3/32 inch thick engraved plastic laminate valve tags, with piping system abbreviation in 1/4 inch high letters and sequenced valve numbers 1/2 inch high, and with 5/32 inch hole for fastener.
 - 1. Provide 1-1/2 inches sq. black tags with white lettering, except as otherwise indicated.
 - 2. Provide size, shape and color combination as specified or scheduled for each piping system.
- OR
- C. Plastic Valve Tags: Provide manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16 inch high letters and sequenced valve numbers approximately 3/8 inch high, and with 5/32 inch hole for fastener.
 - 1. Provide 1-1/8 inches sq. white tags with black lettering.
 - 2. Provide size, shape and color combination as specified or scheduled for each piping system.
 - D. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), and solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

- E. Access Panel Markers: Provide manufacturer's standard 1/16 inch thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8 inch center hole to allow attachment.

2.9 VALVE SCHEDULE FRAMES:

- A. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with non-glare type sheet glass.

2.10 ENGRAVED PLASTIC-LAMINATE SIGNS:

- A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
- B. Thickness: 1/8 inch, except as otherwise indicated.
- C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.11 PLASTICIZED TAGS:

- A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large- size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.12 LETTERING AND GRAPHICS:

- A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, scheduled and approved by the Owner/Engineer. Provide numbers, lettering and wording as indicated and approved by the Owner/Engineer for proper identification and operation/ maintenance of mechanical systems and equipment.
- B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION:

- A. General: Identify air supply, return, exhaust, intake and relief ductwork and duct access doors with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color). Existing building identification shall match the existing method which exists in the building.
- B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50 foot spacing along exposed runs.
- C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment), other maintenance and operating instructions, and appropriate safety and procedural information.
- D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 PIPING SYSTEM IDENTIFICATION:

- A. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow. Existing building identification shall match the existing method which exists in the building.
- B. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non- insulated pipes.

OR

- C. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2 inches beyond ends of lettering.

OR

- D. Stenciled markers, with lettering color complying with ANSI A13.1.

OR

- E. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.
- F. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
- G. Near each valve and control device.
- H. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
- I. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.

- J. At access doors, manholes and similar access points which permit view of concealed piping.
 - K. Near major equipment items and other points of origination and termination.
 - L. Spaced intermediately at maximum spacing of 25 feet along each piping run, except reduce spacing to 15' in congested areas of piping and equipment.
 - M. On piping above removable acoustical ceilings.
- 3.4 UNDERGROUND PIPING IDENTIFICATION:
- A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground- type plastic line marker, located directly over buried line at 6 inches to 8 inches below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16 inches, install single line marker. For tile fields and similar installations, mark only edge pipe lines of field.
- 3.5 VALVE IDENTIFICATION:
- A. General: Provide valve tag on valves in each piping system. List each tagged valve in valve schedule for each piping system.
 - 1. Building services main shut-off valves.
 - 2. Each individual system main shut-off valves.
 - 3. Each individual system riser shut-off valves.
 - 4. Each individual system floor shut-off valves.
 - 5. Each individual system major branch shut-off valves.
 - B. Mount valve schedule frames and schedules in mechanical equipment rooms where directed by Architect/Owner/Engineer.
 - C. Where more than one major mechanical equipment room is shown for project, install mounted valve schedule in each major mechanical equipment room, and repeat only main valves which are to be operated in conjunction with operations of more than single mechanical equipment room.
- 3.6 MECHANICAL EQUIPMENT IDENTIFICATION:
- A. General: Install minimum 2 inch x 4 inch engraved plastic laminate equipment marker on each individual items of mechanical equipment. Provide marker for the following general categories of equipment.
 - 1. Main building systems control and operating valves, including safety devices and hazardous units such as gas outlets.
 - 2. Room thermostats, except gun tag labels are acceptable for room thermostats.
 - 3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption chillers.
 - 4. Pumps, compressors, chillers, condensers and similar motor-driven units.
 - 5. Heat exchangers, cooling towers, heat recovery units and similar equipment.
 - 6. Fans and blowers.
 - 7. Air terminal units.
 - 8. Tanks and pressure vessels.
 - 9. Water treatment systems and similar equipment.
 - B. Lettering Size: Minimum 1/4 inch high lettering for name of unit.

- C. Text of Signs: In addition to the identified unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.7 ADJUSTING AND CLEANING:

- A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
- B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 15190

SECTION 15241 - VIBRATION AND SEISMIC CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of vibration control work required by this section is indicated on drawings and schedules, and/or specified in other Division-15 sections.
1. All mechanical equipment, piping and ductwork as noted or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
 2. It is the intent of the seismic portion of this specification to keep all mechanical and electrical building system components in place during a seismic event.
 3. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturers or construction standards, the most stringent shall apply.
 4. This specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. California Title 24, California OSHPD, Canadian Building Codes, or other requirements.)
 5. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
 6. Seismic restraints shall be designed in accordance with seismic force levels as detailed in Section 1.7.
- B. The work in this section includes, but is not limited to the following:
1. Vibration isolation for piping, ductwork and equipment.
 2. Equipment isolation bases.
 3. Flexible piping connections.
 4. Seismic restraints for isolated equipment.
 5. Seismic restraints for non-isolated equipment.
 6. Certification of seismic restraint designs and installation supervision.
 7. Certification of seismic attachment of housekeeping pads.
 8. All mechanical and electrical systems (installed by Division 15, e.g., Temperature Controls). Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this specification).
- | | |
|-------------------|--------------------|
| AC Units | Air Distrib.Boxes |
| Ductwork | Air Handling Units |
| Control Panels | Air Separators |
| Fans (All types) | Boilers |
| Heat Exchangers | Cabinet Heaters |
| Piping | Cable Trays |
| Pumps (All types) | Chillers |

Rooftop Units	Compressors
Comp. Room Units	Unit Heaters
Conduit	Condensing Units
Water Heaters	Var. Freq. Drives (including isolation transformers)

9. Fire protection systems are excluded from this section; see under separate fire protection sections.
- C. Vibration control products furnished as integral part of factory-fabricated equipment shall comply with the requirements of this section.
- D. For additional and supplemental requirements, refer to other Division 15 sections for equipment foundations; hangers; sealants; gaskets; requirements of electrical connections to equipment isolated on vibration control products; requirements of duct connections to air handling equipment isolated on vibration control products.
- E. Definitions
 1. Life Safety Systems:
 - a. All systems involved with fire protection including sprinkler piping, service water supply piping, fire dampers and smoke exhaust systems. See separate section(s) for fire protection requirements.
 - b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.
 - c. All life safety equipment has an asterisk on the equipment schedule.
 2. Positive Attachment:
 - a. A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.
 3. Transverse Bracing:
 - a. Restraint(s) applied to limit motion perpendicular to the center line of the pipe, duct or conduit.
 4. Longitudinal Bracing:
 - a. Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.
- 1.2 QUALITY ASSURANCE:
 - A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration and seismic control products, of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

1. Except as otherwise indicated, vibration and seismic control products shall be obtained from single manufacturer and shall be certified by the manufacturer.
2. Engage manufacturer to provide technical supervision of installation of support isolation and seismic units produced, and of associated inertia bases (if any).

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of vibration and seismic control product. Submit schedule showing size, type, deflection, and location for each product furnished.
 1. Include data for each type and size of unit, showing specific restraints, isolation efficiency, stiffness, natural frequency and transmissibility at lowest operating speed of equipment detailing compliance with the specification.
 2. For spring units, show wire size, spring diameter, free height, solid-compression height, operating height, fatigue characteristics, ratio of horizontal to vertical stiffness and bases of spring-rated selection for range of loading weights.
 3. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
 4. Include performance certifications from manufacturers.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components. Detail bases, and show location of equipment anchoring points and seismic restraints coordinated with equipment manufacturer's shop drawings.
 1. Shop drawings showing structural design and details of inertia bases, steel beam bases and other custom-fabricated work not covered by manufacturer's submitted data.
 - a. Furnish templates, anchor bolts and sleeve for equipment bases, seismic restraints, foundations and other support systems for coordination of vibration isolation and seismic control units with other work.
 - b. Provide all details of suspension and support for ceiling hung equipment.
 - c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Submittals shall include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.
 - d. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
 2. Submit shop drawings indicating scope of vibration isolation work and locations of units and flexible connections. Include support isolation points for piping and ductwork including risers and inertia bases.

- a. Include schedule of units, showing size or manufacturer's part number, and weight supported and resulting deflection of each unit.
- C. Maintenance Data: Submit maintenance data for each type of vibration and seismic control product. Include this data, product data and shop drawings in maintenance manual; in accordance with requirements of Divisions 15.
- D. Seismic Certification and Analysis:
1. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
 2. All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 degrees to the weakest mode.
 3. Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and-or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section 1.7 acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.
- 1.4 CODE AND STANDARDS REQUIREMENTS:
- A. Applicable Codes and Standards
1. The International Building Code (IBC)
 2. All State and Local Codes.
 3. ASHRAE HVAC Applications Handbook Sound and Vibration Control.
 4. SMACNA Seismic Restraint Manual Guidelines For Mechanical Systems.
- 1.5 MANUFACTURER'S RESPONSIBILITY:
- A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:
1. Determine vibration isolation and seismic restraint sizes and locations.
 2. Provide vibration isolation and seismic restraints as scheduled or specified.
 3. Provide calculations and materials if required for restraint of unisolated equipment.
 4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.
- 1.6 RELATED WORK:
- A. Housekeeping Pads

1. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the drawings.
2. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

B. Supplementary Support Steel

1. Contractor shall supply supplementary support steel for al equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.

C. Attachments

1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

1.7 SEISMIC FORCE LEVELS:

- A. The following force levels will be used on this project based on UBC-94.

MINIMUM "G" FORCES EQUAL TO OR EXCEEDING BUILDING CODE LISTED ABOVE

"G" Forces for All Pipe, Duct & Conduit		"G" Forces for Rigidly Mounted Equipment		"G" Forces for Flexibly Mounted Equipment		"G" Forces for Life Safety Equipment either Rigidly or Flexibly Mounted	
Horiz	Vert	Horiz	Vert.	Horiz	Vert.	Horiz	Vert
N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
0.06	0.02	0.06	0.02	0.1	0.03	0.25	0.07

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by:

1. Vibration and Seismic Control Products:
 - a. Mason Industries, Inc.

- B. Alternate Manufacturer: All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these specifications; products of other manufacturers are acceptable provided their systems strictly comply with the specification and have been reviewed by the Engineer. Submittals and certification sheets shall be in accordance with Section 1.3.
- C. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 inch and/or horizontal permanent deformation greater than 1/4 inch.

2.2 PRODUCT DESCRIPTIONS:

A. Vibration Isolators and Seismic Restraints

The following product descriptions are listed by a number which is used as the identifier for the vibration isolation and seismic control schedule.

1. Two layers of 3/4 inch thick neoprene pad consisting of 2 inches square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.
2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 inches and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Preapproval "R: Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.
3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in 3 planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.
4. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.
5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4 inch neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be Type SLF as manufactured by Mason Industries, Inc.

6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval "R" Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.
7. Not Used
8. Not Used
9. Not Used
10. Hangers shall consist of rigid steel frames containing minimum 1-1/4 inches thick neoprene elements at the top and a steel spring with general characteristics as in Specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degrees capability. Hangers shall be Type 30N as manufactured by Mason Industries, Inc.
11. Hangers shall be as described in 10, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30 degrees capability. Hangers shall be Type PC30N as manufactured by Mason Industries, Inc.
12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.
13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB as manufactured by Mason Industries, Inc.

Note: Specifications 12-14 apply to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze. Specifications apply to hanging equipment as well.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the state of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.
15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the state of California. Clevis cross brace shall be Type CCB as manufactured by Mason Industries, Inc.
16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of ¼ inch thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 inch shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.
17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specification. Elastomeric materials shall be replaceable and a minimum of ¾ inch thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 inch nor more than ¼ inch. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 inch deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ inch deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.
18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.
19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 inches provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 inch. Bases shall be Type WF as manufactured by Mason Industries, Inc.
21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbow. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 inches. The base depth need not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ inch bars welded in place on 6 inches centers running both ways in a layer 1-1/2 inch above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 inch clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.
22. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushing shall be a minimum of ¼ inch thick. Steel springs shall be laterally stable and rest on ¼ inch thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 inches of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load rating. Curb shall be Type RSC as manufactured by Mason Industries, Inc.
23. Flexible spherical expansion joints shall employ peroxide cured U.V. resistant EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 inches and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 inches to 24 inches may be single sphere. Sizes ¾ inch to 1-1/2 inches may have threaded bolted flange assemblies, one sphere and cable retention. 14 inches and smaller connectors shall be rated at 250 psi up to 190 degrees F with a uniform drop in allowable pressure to 190 psi at 250 degrees F. 16 inches and larger connectors are rated 180 psi at 190 degrees F and 135 psi at 250 degrees F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints.

Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods shall be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have ½ inch thick neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 inch and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged		Male Nipples	
3 x 14	10 x 26	1/2 x 9	1-1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
5 x 19	14 x 30	1 x 11	2-1/2 x 18
6 x 20	16 x 32	1-1/4 x 12	
8 x 22			

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS as manufactured by Mason Industries, Inc.

25. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum ½ inch thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be Type ADA as manufactured by Mason Industries, Inc.
26. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½ inch thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of ± 1-5/8 inch motion, or to meet location requirements. Pipe guides shall be Type VSG as manufactured by Mason Industries, Inc.
27. Split Wall Seals consist of two bolted pipe halves with minimum ¾ inch thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to

eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1 inch past either face of the wall. Where temperatures exceed 240 degrees F, 10# density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in Specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of $\frac{1}{4}$ inch movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be Type WBI/WBD as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 PERFORMANCE OF ISOLATORS:

- A. General: Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.
- B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units to achieve minimum static deflection and displacement requirements.

3.3 APPLICATIONS:

- A. General: Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 1995 HVAC Applications Volume, Chapter 43 "Sound and Vibration Control", Table 42 Chapter 40 for Seismic Restraint Design.

3.4 GENERAL:

- A. Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.
- B. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.
- C. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

- D. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
- E. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- F. Coordinate work with other trades to avoid rigid contact with the building.
- G. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architect's/engineer's attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
- H. Bring to the architect's/engineer's attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.
- I. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.
- J. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:
 - 1. Flanges of structural beams.
 - 2. Upper truss cords in bar joist construction.
 - 3. Cast in place inserts or wedge type drill-in concrete anchors.
- K. Specification 12 cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, piping or conduit.
- L. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.
- M. At locations where Specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with Specification 14 braces.
- N. At all locations where Specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with specification type 15 braces.
- O. Drill-in concrete anchors for ceiling and wall installation shall be Specification Type 18, and Specification Type 19 female wedge type for floor mounted equipment.
- P. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.
- Q. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces.
- R. Hand built elastomeric expansion joints maybe used when pipe sizes exceed 24inches or specified movements exceed Specification 23 capabilities.

- S. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Specification 27 wall seals.
 - T. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be Specification Type 28.
 - U. Locate isolation hangers as near to the overhead support structure as possible.
 - V. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
 - W. Install inertia base frames on isolator units so that minimum of 1 inch clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.
 - X. For air handling equipment, install thrust restraints as indicated, and also wherever thrust exceeds 10 percent of equipment weight.
 - Y. Weld riser isolator units in place as required to prevent displacement from loading and operations.
 - Z. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.
- 3.5 VIBRATION ISOLATION OF PIPING:
- A. Seismic Restraint of Piping
 - 1. Seismically restrain all piping listed as a, b or c below. Use Specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.
 - a. Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1 inch I.D. or larger.
 - b. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1-1/4 inch I.D. and larger.
 - c. All other piping 2-1/2 inch diameter and larger.
 - 2. Transverse piping restraints shall be at 40 feet maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - 3. Longitudinal restraints shall be 80 feet maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - 4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
 - 5. For all gas piping transverse restraints shall be at 20 feet maximum and longitudinal restraints at 40 feet maximum spacing.

6. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 inches of the elbow or TEE or combined stresses are within allowable limits at longer distances.
7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
8. Branch lines may not be used to restrain main lines.
9. Cast iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly shall be braced in accordance with seismic product manufacturer's recommendations and SMACNA Seismic Restraint Manual Guidelines For Mechanical Systems.

B. Seismic restraint of duct work

1. Seismically restrain all duct work with Specification 12 or 13 restraints as listed below:
 - a. Restrain rectangular ducts with cross sectional area of 6 sq. feet or larger.
 - b. Restrain round ducts with diameters of 28 inches or larger.
 - c. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
2. Transverse restraints shall occur at 30 foot intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
3. Longitudinal restraints shall occur at 60 foot intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4 feet of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
4. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
5. A group of ducts may be combined in a larger frame so that the combined weight and dimensions of the duct for which bracing details are selected.
6. Walls, including gypsum board non-bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

C. Seismic Restraint of Electrical Services (Applicable To All Division 15 Electrical Wiring Requirements):

1. All electrical conduit 2-1/2 feet in diameter and larger shall be restrained with Specification Type 12 seismic cable restraints or Specification 13 for seismic solid brace restraints.
2. All electrical bus ducts, cable trays and ladder trays shall be restrained with Specification Type 12, seismic cable restraints or Specification 13 seismic solid brace restraints.

3. Transverse restraints shall occur at 30 foot intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.
 4. Longitudinal restraints shall occur at 60 foot intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a duct for an electric section connected perpendicular to it if the restraints are installed within 4' of the intersection of the electric run and if the restraints are sized for the larger electric run.
 5. All rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Anchor bolts shall be designed in accordance with Section 1.06 seismic forces. Neoprene bushings shall be Specification Type 4 and anchor bolts shall be Specification Type 18 or 19.
- D. All mechanical equipment shall be vibration isolated and seismically restrained as per the schedules in Part 4 of this specification.

3.6 SEISMIC RESTRAINT EXCLUSIONS:

A. Piping

1. All piping less than 2-1/2 Inches in diameter except those listed below.
2. All gas piping, fuel oil piping and medical gas piping less than 1 inch I.D.
3. All piping in boiler and mechanical equipment rooms less than 1-1/4 inch I.D.
4. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 inches in length from the structure to the structural connection of the clevis or trapeze.
5. All PVC and fiberglass suspended waste or vent pipe 6 inches in diameter and smaller.

B. Duct Work

1. Rectangular, square or oval ducts less than 6 sq. feet in cross sectional area.
2. Round duct less than 28 inches in diameter.
3. Duct supported by hanger rods where the point of attachment is less than 12 inches in length from the structure to the structural connection of the duct work.

C. Electrical

1. All conduit less than 2-1/2 inches in diameter suspended by individual hanger rods.
2. All clevis or trapeze supported conduits suspended by hanger rods where the point of attachment is less than 12 inches in length from the structure to the structural connection of the clevis or trapeze.

D. Suspended Equipment

1. Terminal boxes and fan powered equipment weighing less than 50 lbs. and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

3.7 EXAMINATION OF RELATED WORK:

- A. Installer of vibration isolation work shall observe installation of other work related to vibration isolation work, including work connected to vibration isolation work; and, after completion of other related work (but before equipment startup), shall furnish written report to Engineer listing observed inadequacies for proper operation and performance of vibration isolation work. Report shall cover, but not necessarily be limited to the following:
 - 1. Equipment installations (performed as work of other sections) on vibration isolators.
 - 2. Piping connections including flexible connections.
 - 3. Ductwork connections including provisions for flexible connections.
 - 4. Passage of piping and ductwork which is to be isolated through walls and floors.
- B. Do not start-up equipment until inadequacies have been corrected.

3.8 ADJUSTING AND CLEANING:

- A. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short- circuit unit isolation.

3.9 DEFLECTION MEASUREMENTS:

- A. Upon completion of vibration isolation work, prepare report showing measured equipment deflections theoretical floor deflection and isolation efficiency for each major item of equipment.

PART 4 - SCHEDULES

4.1 EQUIPMENT ISOLATOR AND SEISMIC RESTRAINT SCHEDULE:

EQUIPMENT SCHEDULE	VIBRATION ISOLATION AND/OR SEISMIC RESTRAINT	
	SPECIFICATION	STATIC DEFLECTION

END OF SECTION 15241

SECTION 15250 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products and systems, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- C. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.

1.2 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, density, and furnished accessories for each mechanical system requiring insulation. Submit detail product information and installation information for all jacketing systems specified in this section.

1.3 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

- 1. Mechanical Insulation:
 - a. Johns Manville Corp.
 - b. Owens-Corning Fiberglas Corp.
 - c. Knauf Fiber Glass
 - d. Manson
 - e. Armstrong World Industries, Inc.
 - f. Pittsburgh Corning Corp.
 - g. PABCO, Inc.
 - h. Rubatex Corp.
 - i. Thermal Ceramics

- j. Thermal Structures
- 2. Jacketing & Covering Products:
 - a. Childers
 - b. Ceel-Co
 - c. Zeston
 - d. Alpha Associates, Inc.
- 3. Sound Lagging/Insulation
 - a. Soundseal
 - b. Vibro-Acoustics
 - c. Schuller
 - d. Owens-Corning
 - e. Certainteed

2.2 PIPING INSULATION MATERIALS:

- A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. "K" factor shall be maximum 0.24 at 75 degrees F. mean temperature, jacket with tensile strength of 35 lbs/in, mullen burst 70 psi, beach puncture 50 oz. in/in, permeability .02 perm factory applied vapor barrier jacket and adhesive self-sealing lap joint.
- B. Cellular Glass Piping Insulation: ASTM C 552, Type II, Class 2. "K" factor shall be maximum 0.29 at 75 degrees F mean temperature.
- C. Calcium Silicate Piping Insulation: ASTM C 533, Type I. "K" factor shall be maximum 0.45 at 500 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 200 psi for 5 percent compression, flexural strength 60 psi.
- D. Flexible Closed Cell Piping Insulation: ASTM C 534, Type I. "K" factor shall be maximum 0.27 at 75 degrees F. mean temperature, with a water vapor permeability of 0.10 perm inches or less. Insulation shall be pre-installed on piping, or un-slitted to be slipped over piping as a single piece.
- E. Flexible Thermal Ceramic Insulation [[Fiber Retractory, Ceramic Fiber](#)]: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degreeed F temperature limit. Provide presized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, unless otherwise indicated.
- F. Rigid Thermal Ceramic Insulating System: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degrees F temperature limit.
- G. Jackets for Piping Insulation: ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.
 - 1. Fitting Covers: UV resistant PVC, pre-molded fitting covers, flame spread 25, smoke developed 50. PVC tape for cold systems, serrated tacks or PVC tape for hot systems.
 - 2. Aluminum Jacketing: Manufactured from T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16" corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing. Jacketing shall be .016" thick minimum. Provide matching factory fabricated covers for 90 degrees and 45

degrees elbows, tee fittings, flange fittings valve bodies, blind ends, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof.

3. Rubber/Tedlar Jacketing: ASTM-D-1424-63, ASTM-D-774, and ASTM-E-84, manufactured from a combination of heavy fiberglass fabric coated with Hypalon Rubber, fully cured and laminated to a Tedlar facing. Jacketing will also be required to be vapor barrier and shall be laminated to a corrosion resistant aluminized mylar. Jacketing shall be .010" thick minimum, UL Class I rated, acid and alkali resistant, and be both washable and paintable. Provide factory fabricated aluminum fitting covers with mil-polyethylene vapor barrier for all elbows, tees, flanges, valves, and other fittings. Alpha Associates Style TGH-1000 or equal.
4. Cloth Jacketing Material: Not less than 8 oz. per square yard with adhesives, cement and sealer as recommended by insulation manufacturer for the intended application. PVC premolded fitting covers shall not be provided.

H. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

I. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated and additional finishes as specified.

2.3 DUCTWORK INSULATION MATERIALS:

- A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1, 450 degrees F temperature limit, density of 3 pcf. "K" value shall be maximum 0.23 at 75 degrees F. mean temperature, facing of 7 mil, foil reinforced with glass mesh and laminated to 40 lb kraft.
- B. Round Surface Semi-Rigid Fiberglass Blanket Insulation: ATSM C 612, Class 1, 450 degrees F temperature limit, 2.5 PCF density "K" value of .25 max at 75 degrees F mean temp, foil-skrim-kraft facing. Orientation of fibers shall be perpendicular to facing to facilitate application on round surfaces.
- C. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, 3/4 lbs per cu. ft. density. "K" value shall be maximum 0.25 at 75 degrees F. mean temperature, 250 degreed F temperature limit, vapor transmission rating shall not exceed 0.02 perms, facing of .7 mil foil reinforced with glass mesh and laminated to 40 lb kraft.
- D. Flexible closed cell elastomeric insulation: ASTM C534, Type I, "K" value shall be a maximum 0.27 at 75 degrees F mean temp, 220 degrees F Temperature limit, water vapor permeability rating of 0.10 perm inches or less.
- E. Jackets for Ductwork Insulation: ASTM C 921, Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient.
 1. Aluminum Jacketing: The jacketing shall be manufactured from T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16 inch corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing. Jacketing shall be .016 inches thick minimum. Where available, provide matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, branch fittings, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof. All jacketing shall be color coated baked on polyester finish, color selected by Architect.

OR

Rubber/Tedlar Jacketing: ASTM-D-1424-63, ASTM-D-774, and ASTM-E-84, manufactured from a combination of heavy fiberglass fabric coated with Hypalon Rubber, fully cured and laminated to a Tedlar facing. Jacketing will also be required to be vapor barrier and shall be laminated to a corrosion resistant aluminized mylar. Jacketing shall be .010" thick minimum, UL Class I rated, acid and alkali resistant, and be both washable and paintable. Provide factory fabricated aluminum fitting covers with mil-polyethylene vapor barrier for all elbows, tees, and other fittings. Alpha Associates Style TGH-1000 or equal.

OR

Flexible closed cell elastomeric insulation shall be coated with two coats Armstrong WB Armaflex Finish

- F. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
- G. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

2.4 EQUIPMENT INSULATION MATERIALS:

- A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2. "K" factor shall be maximum 0.28 at 200 degrees F. mean temperature, 3.0 lb. density, 850\ degrees F temperature limit.
- B. Flexible Fiberglass Equipment Insulation: ASTM C 553, Type I, "K" factor shall be maximum 0.45 at 250 degrees F. mean temperature. 850 degrees F temperature limit.
- C. Calcium Silicate Equipment Insulation: ASTM C 533, Type I, Block. "K" factor shall be maximum 0.87 at 1000 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 60 psi.
- D. Flexible closed cell elastomeric insulation: ASTM C534, Type I, "K" valve shall be a maximum of 0.27 at 75 degrees F mean temp, 220 degrees F temperature limit, water vapor permeability of 0.10 perm inches or less.
- E. Jacketing Material for Equipment Insulation: Provide pre- sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.
- F. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
- G. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

2.5 SOUND LAGGING/INSULATION:

- A. Flexible Fiberglass & Vinyl Sound Insulation: 1.0 PSF, .090 inch thick mylar feed vinyl loaded barrier, tested to 400psi tensile strength. Absorber material, foil covered fiberglass laminated on

vinyl barrier, .40 PSF, 2 inch nominal thickness insulating value of R-8.0. Assembly flame/smoke index of 12.5/19.5 tested per Class A ASTM E-84. Assembly sound tested per ASTM E-90 for a STC of 30 or greater. Rated for temperature between -20 degrees F & 350 degrees F. Provide soundseal B-10LAG/AFA-9 or approved equal.

SOUND TRANSMISSION LOSS (dB) FREQUENCY (Hz)						
PRODUCT	125	250	500	1000	2000	4000
B-10 LAG 1 QFA-9	19	20	23	33	44	53

- B. Sound lagging foil tape: 4" x 200' rolls of matching foil tape by Soundseal.
- C. Insulation for application over duct, piping & equipment.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
- B. Workmanship shall be first class and of the highest quality, poor installation or bad appearance as determined by the engineer shall be due cause to reject the entire project in whole and retainage will be withheld until corrective action is completed to the engineer's satisfaction.

3.2 PLUMBING PIPING SYSTEM INSULATION:

- A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, fire protection piping, and pre-insulated equipment.
- B. Cold Piping:
 - 1. Application Requirements: Insulate the following cold plumbing piping systems:
 - a. Potable and non-potable cold water piping.
 - b. Potable chilled water piping.
 - c. Interior above-ground horizontal storm water piping including elbow up & down.
 - d. Roof drain bowls and roof drain leader to horizontal piping.
 - e. Overflow roof drain bowls and first 10 feet of overflow piping.
 - 2. Insulate each piping system specified above with the following types and thicknesses of insulation:
 - a. Above Ground Inside Building Fiberglass; ½ inch thickness.
- C. Hot Piping:
 - 1. Application Requirements: Insulate the following hot plumbing piping systems:

- a. Potable hot water and tempered piping.
 - b. Potable hot water and tempered recirculating piping.
2. Insulate each piping system specified above with the following types and thicknesses of insulation:
- a. Fiberglass; 1/2inch for runouts to individual fixtures 12'-0" or less in length, 1 inch thick for pipe sizes up to and including 2inch, 1-1/2 inch thick for pipe sizes over 2 inches.

3.3 HVAC PIPING SYSTEM INSULATION:

- A. Insulation Omitted: Omit insulation on hot piping unions, flexible connections, and expansion joints. Insulation may be omitted inside of cabinet unit heaters, convectors and fan coils for hot piping. Cold piping insulation inside fan coil unit cabinet may be omitted provided piping is located over drain pan. Hot and cold piping routed inside air handler units shall be insulated. Omit insulation on strainers in heating water strainers operating below 200 degrees F.

Edit Note: The general industry standard is fiberglass. Cellular glass is a specialty product, but is superior in moisture resistance, and should be considered in exterior, underground, or high humidity applications. Verify local installers are familiar with the product, and any cost implications.

- B. Cold Piping (40 degrees F (4.4 degrees C) to ambient):

1. Application Requirements: Insulate the following cold HVAC piping systems:
 - a. Chilled water supply and return piping.
 - b. Cold condensate drain piping.
 - c. Condenser water supply and return piping when used with plate and frame or cooling coil applications.
2. Insulate each piping system specified above with the following types and thicknesses of insulation:
 - a. Fiberglass: 1/2inch thick for runouts to individual units up to 2inches in size and less than 12feet-0 inches in length, 1inch thick for pipe sizes up to and including 8 inch, 1-1/2inch thick for pipe sizes over 8 inches.
 - b. Exterior, Above Ground - Cellular Glass: 1/2inch thick for runouts to individual units up to 2inches in size and less than 12foot-0inches in length, 1inch thick for pipe sizes up to and including 2inch, 2inch thick for pipe sizes over 2inches.
 - c. Below Ground - Flexible Elastomeric: 1/2inch thickness for pipe sizes up to 2inches.

- C. Heating System Piping (to 200 degrees F (90 degrees C)):

1. Application Requirements: Insulate the following heating piping systems:
 - a. Hot water supply and return piping.
 - b. Hot gas refrigerant piping (interior, exposed, less than 7feet-6inches above floor).
 - c. Hot gas bypass refrigerant piping (interior, exposed, less than 7feet-6inches above floor).

2. Insulate each piping system specified above with the following type and thicknesses of insulation:
 - a. Fiberglass: 1/2inch thick for runouts to individual units up to 2inches in size and less than 12feet-0inches in length, 1-1/2inches thick for pipe sizes up to and including 8inch, 2inch thick for pipe over 8inches.
 - b. Above Ground Exterior - Cellular Glass: 2inches thick for pipe sizes up to and including 8inches, 2-1/2inch thick for pipe sizes 8".
 - c. Underground Piping to Individual Terminal Units - Flexible Elastomeric: 1/2inch thick up to 2inch pipe size.

3.4 DUCTWORK SYSTEM INSULATION:

- A. Insulation Omitted: Do not insulate fibrous glass ductwork, or lined ductwork.
- B. Application Requirements: Insulate the following ductwork:
 1. Outdoor air intake ductwork and plenums between air entrance and fan inlet or HVAC unit inlet.
 2. Mixed air ductwork and plenums between air entrance and fan inlet or HVAC unit inlet.
 3. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet unless ductwork is specified to be lined.
 4. HVAC return ductwork in unconditioned spaces or exterior; except omit insulation when ductwork is specified to be lined.
 5. HVAC plenums and unit housings not pre-insulated at factory or lined.
 6. Rigid oval or round supply air ductwork.
- C. Insulate each ductwork system specified above with the following types and thicknesses of insulation:

APPLICATION	TYPE, THICKNESS		
	RIGID/ FIBERGLASS (see notes 1&2)	FLEXIBLE FIBERGLASS	FLEXIBLE ELASTOMERIC**
Interior; concealed; cold, hot or dual temperature duct	1" min. up to 2" as required to cover joints & reinforcements	1-1/2"	1"
Interior; exposed within conditioned finished spaces; cold, hot, or dual temperature duct	None 1" min. up to 2" as required to cover joints & reinforcements	None Not Allowed except for budget considerations	None 1" min. up to 2" as required to cover joints & reinforcements. Provide white finish coat.

Interior; exposed within mechanical, electrical, storage, or other service areas; cold, hot, or dual temperature duct	1" min. up to 2" as required to cover joints and reinforcements	Not Allowed except for budget considerations	1" min. up to 2" as required to cover joints and reinforcements with white finish. Provide white finish coat.
Exterior; hot or dual temperature duct, all return duct	Not Allowed	Not Allowed	2" with metal jacket <u>OR with weather protective finish OR with rubber/Tedlar jacket</u>
Edit Note #1: Use semi-rigid fiberglass insulation for round or flat oval duct			

3.5 EQUIPMENT INSULATION:

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:
 - a. Refrigeration equipment, including chillers, tanks and pumps, including any cold surfaces not factory insulated.
 - b. Condensate pans under chilled equipment.
 - c. Chilled water pumps.
 - d. Air separators.
2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
 - a. Rigid Fiberglass: 1inch thick for surfaces above 35 degrees F (2 degrees C) and 1-1/2inch thick for surfaces 35 degrees F (2 degrees C) and lower.
 - b. Flexible Elastomeric Sheet: 3/4 inch thickness for surface temperatures above 35 degrees F (2 degrees C), 1inch thickness for surface temperatures below 35 degrees F (2 degrees C).

B. Hot Equipment (Above Ambient Temperature):

1. Application Requirements: Insulate the following hot equipment:
 - a. Boilers (not pre-insulated at factory).
 - b. Water heaters (not pre-insulated at factory)
 - c. Heat exchangers.
 - d. Air separators.
2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
 - a. Fiberglass: 2inch thick, except 3inch thick for low- pressure boilers and steam-jacketed heat exchangers. Do not use for equipment above 450 degrees F (232 degrees C).

- b. Calcium Silicate: 3inch thick, except 4inch thick for diesel exhaust mufflers and 4-1/2 inches thick for low-pressure boilers and steam-jacketed heat exchangers.
3. Application Requirements: Insulate the following breechings and stacks:
 - a. Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.
 - b. Stacks from bottom to top except for factory insulated stacks.
4. Insulate each breeching and stack specified above with the following types and thicknesses of insulation:
 - a. Calcium Silicate: 4inches thick (2 layers of 2 inch thickness).

3.6 INSTALLATION OF PIPING INSULATION:

- A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
- B. Install insulation on pipe systems subsequent to installation of heat tracing, testing, and acceptance of tests.
- C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
- D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- E. Maintain integrity of vapor-barrier jackets on cold pipe insulation, and protect to prevent puncture or other damage.
 1. Do not use staples or tacks on vapor barrier jackets.
 2. Seal vapor barrier penetrations with vapor barrier finish recommended by the manufacturer.
 3. Seal fitting covers with PVC tape.
 4. Cover all unions, check valves, and other in-line devices. Mark outer covering with indelible marker to identify item covered.
- F. Neatly bevel and seal insulation at all exposed edges.
- G. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
- H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
- I. See equipment insulation for removable insulation on accessible piping components.

J. See Section 15140 for insulation inserts and shields. Butt pipe insulation against pipe hanger insulation inserts. For all piping apply wet coat of vapor barrier lap cement on butt joints and seal all joints and seams with 3 inch wide vapor barrier tape or band.

K. Flexible Elastomeric Piping Insulation:

1. Install unslit, by slipping over piping prior to joining, or install pre-insulated soft copper tubing.
2. Seal butt ends with adhesive.

L. Cellular Glass Insulation:

1. Apply in a single layer. Secure to pipe with ½ inch wide aluminum bands.
2. For indoor applications, apply all purpose Kraft paper/aluminum foil/vinyl coating jacket. Seal all lap and butt joints with self seal vapor barrier tape.
3. For outdoor applications, apply aluminum rubber/Tedlar jacketing as described below.

M. Calcium Silicate Insulation:

1. Apply in a single layer. Secure to pipe with 1/2inch wide aluminum bands.
2. For indoor applications, provide canvas jacketing. Adhere joints of jacketing and provide a finish coat of sealant as recommended by the manufacturer.

3.7 INSTALLATION OF DUCTWORK INSULATION:

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

1. Avoid the use of staples on vapor barrier jackets.
2. Seal vapor barrier penetrations with vapor barrier tape recommended by the manufacturer.

E. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

F. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

G. Flexible Fiberglass Insulation: Cut back insulation to provide a 2inch facing overlap at all seams. Seams shall be stapled approximately 6 inches on center with outward clinching staples, then sealed with pressure-sensitive tape matching the facing and designed for use with duct insulation. The underside of ductwork 24inches or greater shall be secured with mechanical

fasteners and speed clips spaced approximately 18 inches on center. The protruding ends of the fasteners should be cut off flush after the speed clips are installed, and then sealed with the same tape as specified above.

- H. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on all external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.
- I. Adhere flexible elastomeric sheets to clean oil-free metal surface by compression fit method and full coverage of adhesive. Seal butt joints with same adhesive. For exterior ductwork, notch insulation at reinforcements and joint flanges to provide a smooth surface, unless the reinforcements or joints would penetrate the insulation. Provide a minimum 1/2 inch cap over any penetrating item. Stagger all joints and seams on multi-layer insulation.

3.8 INSTALLATION OF EQUIPMENT INSULATION:

- A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose. Complete finishes as specified.
- B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.
- C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- D. Do not apply insulation to equipment, mufflers, breechings, or stacks while hot.
- E. Apply insulation using staggered joint method and double layer construction. Apply each layer of insulation separately.
- F. Insulation board shall be cut and mitered to fit the contour of the vessel and shall be applied with edges tightly butted, joints staggered where two or more layers are necessary (due to available thickness of insulation) and secured with 1/2 inch x 0.015 inch galvanized steel bands on 12 inch centers or with weld pins or stick clips with washers on 18 inch centers.

Coat insulated surfaces with layer of insulating cement, cover the insulation, 1 inch galvanized wire mesh shall be tightly stretched in place with edges tied together and finished between two coats of insulating cement troweled to a hard finish (not less than 1/4 inch thick).

OR

Troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions and to remove surface irregularities.

OR

Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2". Apply over vapor barrier where applicable.

- G. Do not insulate hot equipment ASME stamp and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

H. Cold equipment requiring access: Provide removable section of insulation, fabricated from flexible elastomeric insulation, adhered to an aluminum jacket, and joined with velcro strips around entire perimeter. Reinforce removable section and adjoining insulation at attachment points. Removable insulation shall be provided for all equipment requiring periodic inspection, access or maintenance including:

1. Chilled water pump bodies.
2. Strainer basket access.
3. Heat exchanger (including chillers) tube access.
4. Handhold/cleanout covers.

3.9 EXISTING INSULATION REPAIR:

A. Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period. Use insulation, install new jacket lapping and sealed over existing.

3.10 PROTECTION AND REPLACEMENT:

- A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 15250

SECTION 15300 - FIRE PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. This Section specifies automatic sprinkler systems for buildings and structures. Materials and equipment specified in this Section include:
 - Pipe, fittings, valves and specialties.
 - Sprinklers and accessories.
- B. Products furnished but not installed include sprinkler head cabinet with spare sprinkler heads. Furnish to the Owner's maintenance personnel.
- C. The work of this section includes engineering by the Contractor. The Contractor shall act as Engineer of record for all fire protection work.
- D. The fire protection system work is an extension of the existing fire protection system. Provide all modifications to the existing system as required to complete the new work. Provide hydraulic calculations and shop drawings where required by the extent of the work or by the authority having jurisdiction.

1.2 DEFINITIONS:

- A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).
- B. Other definitions for fire protection systems are listed in NFPA Standards 13, 13R, 14, 20 and 24.
- C. Working plans as used in this Section means those documents (including drawings and calculations) prepared pursuant to the requirements contained in NFPA 13 and 14 for obtaining approval of the authority having jurisdiction.

1.3 SYSTEM DESCRIPTION:

- A. Provide a complete fire sprinkler system for the entire building (including, but not limited to, electrical rooms, mechanical penthouses and accessible sections of air handling units,) except designated areas as shown on the drawings which will not require fire sprinkler coverage will be specifically noted with "No A/S"
- B. Fire protection system is a "wet-pipe" system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by fire.
- C. Elevator Shafts and Machine Rooms: Sprinklers shall be installed in elevator machinery rooms, at the top of elevator shafts, and at the bottom of elevator shafts.
 - 1. Sprinkler coverage shall be designed for Ordinary Hazard Group One. Sprinkler heads shall be high temperature classification (286 degrees F.).

2. The sprinkler heads in the elevator machinery room shall be supplied from a separate, independent sprinkler branch line with a readily accessible indicating shut-off valve located outside of the shaft or machinery room.
3. At least one smoke detector shall be located in the same area of each sprinkler head. Activation of any one of these detectors shall cause emergency recall (if equipped) of the elevator(s) and also put the building into alarm.
4. In addition to smoke detectors, at least one thermal detector, with 190 degrees F. fixed temperature, shall be installed in the same area of each sprinkler head. The circuitry for the thermal detector(s) shall be separate from the circuitry for the smoke detector(s). When any thermal detector is activated, a shunt-trip circuit breaker shall automatically disconnect all electrical power to the elevator machinery room and the elevator machinery.
5. Division 16 shall provide Fire Detection System (detectors, wiring, panel, etc.) for complete operation of the Fire Sprinkler System for the elevator shaft and machine room.

1.4 PROJECT SEISMIC REQUIREMENTS:

- A. All fire protection systems shall be installed to meet NFPA and IBC Seismic Zone [] requirements.
 1. Where any conflicts arise the more stringent requirements shall be applicable.

1.5 SUBMITTALS:

- A. Product data for each type sprinkler head, valve, piping and piping specialty, fire protection specialty, fire department connection and any equipment installed in accordance with the Contract Documents. Index per specification chapter and item number.
- B. Shop drawings prepared in accordance with NFPA 13 identified as "working plans," including detailed riser schematics indicating pipe sizes and lengths; and hydraulic calculations where applicable, which have been approved by the authority having jurisdiction. Do not proceed with the installation of the work until the Architect/Engineer review of shop drawings is received.
- C. Contractor shall stamp shop drawings indicating compliance with applicable codes and contract drawings. Contractor shall stamp drawing "Approved for Construction."
- D. If more than two submittals (either for shop drawings or for record drawings) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.
- E. Maintenance data for each type sprinkler head, valve, piping specialty, fire protection specialty, fire department connection and hose valve specified, for inclusion in operating and maintenance manual specified in Division 1 and Division-15 Section "Basic Mechanical Requirements."
- F. Welder's qualification certificate.

- G. Test reports and certificates including "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Materials and Test Certificate for Underground Piping" as described in NFPA 13.
 - H. Hydraulic calculations and drawings submitted to the Engineer shall be prepared under the direct supervision of and bear the signed stamp of a professional engineer registered in the State of Colorado and familiar with this type of installation and with previous similar experience (practicing in the Fire Protection field) certifying that the fire sprinkler system has been designed and hydraulically calculated in compliance with NFPA and governing codes.
 - I. Fire sprinkler piping design drawings shall show all ductwork, air devices, lighting and electrical panels.
 - J. Shop drawings and hydraulic calculations shall be stamped and signed by the local fire prevention authority prior to submitting shop drawings to the Architect/Engineer.
- 1.6 HYDRAULIC DESIGN:
- A. The Fire Sprinkler System shall be hydraulically calculated by the Contractor. Pipe schedule method is acceptable only as allowed in NFPA 13 5-2.2.
 - B. The wet pipe fire sprinkler system for the building shall be hydraulically calculated to comply with NFPA-13 and the following criteria:
 - 1. Light hazard occupancy for areas unless noted otherwise.
 - 2. Hose allowance shall comply with NFPA-13.
 - C. The final fire protection system demand shall be a minimum of 10 PSI below the water supply curve.
 - D. Velocities in pipes shall be shown on hydraulic calculations. Velocities in overhead piping shall not exceed 32 feet per second. Velocities in underground piping shall not exceed 16 feet per second.
 - E. Allow 10 feet of loss for electric water flow switches and note on hydraulic calculations.
 - F. The Fire Protection Contractor shall provide as many sets of hydraulic calculations as necessary, performed and submitted to prove that the most remote and demanding areas are calculated.
 - G. Design information shall be permanently affixed to the main riser as described in NFPA Pamphlet 13.
 - H. Water flow data for bidding purposes only is:
 - [] psi static
 - [] psi residual with [] gpm flowing
 - I. The Fire Protection Contractor shall be responsible for water flow data from the appropriate water department. A copy of the water flow test data from the water department shall accompany the hydraulic calculations before hydraulically calculating equipment fire sprinkler system.

- J. The pipe and valve sizes indicated on the drawings and details are minimum sizes to be used regardless of sizes allowed by hydraulic calculations.

1.7 QUALITY ASSURANCE:

- A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by qualified installer. The term qualified means experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with all precautions required, and has complied with all the requirements of the authority having jurisdiction. The contractor shall be licensed for the design and installation for the specific type of system in the jurisdiction where the work is to be performed and the State of Colorado. Upon request, submit evidence of such qualifications to the Engineer. Refer to Division-1 Section: "Definitions and Standards" for definitions for "Installers."
- B. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, Specifications of Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."
- C. Regulatory Requirements: Comply with the requirements of the following codes:
 - 1. NFPA 13 - Standard for the installation of Sprinkler System, including applicable seismic requirements.
 - 2. NFPA 13R - Standard for the Installation of Sprinkler Systems in residential occupancies up to four stories.

EDIT NOTE: Verify with Owner insurance requirements to specify FM or IRI.

- 3. UL [and FM](#) Compliance: All fire protection system materials and components shall be Underwriter's Laboratories [and Factory Mutual](#) listed as well as labeled for the application anticipated.
 - 4. National Electrical Code (NEC).
 - 5. Uniform Building Codes, including applicable seismic requirements.
 - 6. Requirements of the local Building Department and Fire Department.
- D. Reference and standards listed are minimum requirements. Where more stringent requirements are specified or noted on the drawings, this shall be applicable.

1.8 SEQUENCING AND SCHEDULING:

- A. Schedule rough-in installations with installations of other building components.
- B. Minimum time frame for notice of inspections, tests and meetings is five (5) days and list the persons to be notified.

1.9 EXTRA STOCK:

- A. Heads: For each style and temperature range (and length for dry heads) required, furnish additional sprinkler heads per NFPA-13.
 - 1. Obtain receipt from Owner that extra stock has been received.

- B. Wrenches: Furnish 2 spanner wrenches for each type and size of valve connection and fire hose coupling.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS:

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in fire protection systems.
- B. All equipment used on this project shall be new and UL listed unless noted or specified otherwise.

2.2 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide fire protection system products from one of the following:
 - 1. Gate Valves:
 - a. Nibco
 - b. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
 - c. Mueller
 - d. Stockham
 - e. Grinnell
 - f. Milwaukee
 - 2. Swing Check Valves:
 - a. Central
 - b. Mueller
 - c. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
 - d. Star Sprinkler Corp.
 - e. Viking
 - f. Victaulic
 - g. Globe
 - h. Potter Roemer
 - 3. Butterfly and Ball Valves:
 - a. Grinnell
 - b. Mueller
 - c. Victaulic
 - d. Milwaukee
 - e. Kennedy
 - 4. Grooved Mechanical Couplings:
 - a. Gruklok
 - b. Victaulic Company of America
 - c. Central Sprink, Inc.

5. Double Check Valve Assembly:
 - a. Febco Model 850
 - b. Watts Model 709
 - c. Conbraco 40-100
 - d. Ames Model 2000 (epoxy)

EDIT NOTE: When using reduced pressure backflow preventer, provide large floor sink. See code book and manufacturer's data for capacities.

6. Compact Double Check Assembly:
 - a. Febco Model 870/870V
7. Reduced Pressure Backflow Assembly:
 - a. Febco Model 860
 - b. Watts 909
 - c. Conbraco 40-200
 - d. Ames 4000 Rp (epoxy)
8. Compact Reduced Pressure Backflow Assembly:
 - a. Febco Model 880/880V
9. Fire Protection Specialty Valves
 - a. Reliable Automatic Sprinkler Co., Inc.
 - b. Star Sprinkler Corporation
 - c. Viking Corporation
 - d. Central
 - e. Globe
 - f. Grinnell/Gem
10. Fire Department Connection:
 - a. Croker
 - b. Potter-Roemer
 - c. Elkhart
 - d. Grinnell/Gem
11. Sprinkler Heads:
 - a. Automatic Sprinkler Corp. of America.
 - b. Central Sprinkler Corp.
 - c. ITT Grinnell
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Star Sprinkler Corp.
 - f. Viking Corp.
 - g. Globe
12. Fire Protection Specialties:

- a. Croker-Standard Div.,; Fire-End & Croker Corp.
- b. Elkhart Brass Mfg. Co., Inc.
- c. Grinnell Fire Protection Systems Co., Inc.
- d. Grunau Sprinkler Mfgr. Co., Inc.
- e. Potter Roemer, Inc.

13. Inspector's Test and Drain Module

- a. Victaulic
- b. A.G.F.
- c. Grinnell/Gem

2.3 BASIC IDENTIFICATION:

- A. General: Provide identification complying with Division-15 "Mechanical Identification", in accordance with the following listing:

1. Fire Protection Piping: Pipe markers.
2. Fire Protection Valves: Valve tags.
3. Fire Protection Signs: Provide the following signs:
 - a. At each sprinkler valve, sign indicating what portion of system valve controls.
 - b. At each outside alarm device, sign indicating what authority to call if device is activated.
 - c. At door to each sprinkler control valves [or at ceiling access points](#), sign reading "FIRE CONTROL".
 - d. At each drain or test, sign indicating its purpose.

- B. Attach to the riser a metal sign indicating the name, address and telephone number of the fire protection contractor. Also indicate the date of installation.

2.4 BASIC PIPING SPECIALTIES:

- A. General: Provide piping specialties complying with Division-15 Basic Mechanical Materials and Methods section "Piping Specialties", in accordance with the following listing:

1. Pipe escutcheons.
2. Dielectric unions.
3. Drip pans.
4. Pipe sleeves.
5. Sleeve seals.
6. Fire Barrier Penetration Seals.

2.5 BASIC SUPPORTS AND ANCHORS:

- A. General: Provide supports and anchors complying with Division-15 "Supports and Anchors" in accordance with the following listing:

1. Adjustable steel clevis hangers, adjustable steel band hangers, or adjustable band hangers, for horizontal-piping hangers and supports.

2. Two-bolt riser clamps for vertical piping supports.
3. Steel turnbuckles and malleable iron sockets for hanger- rod attachments.
4. Concrete inserts, top-beam C-clamps, side beam or channel clamps or center beam clamps for building attachments.
5. Concrete inserts and other type hangers penetrating into or through structural members shall be submitted (by the Fire Protection Contractor) to and have the approval of the structural engineer contracted for this project.
6. Powder driven studs shall not be allowed.
7. Hangers (which are acceptable for project)and hanger spacing shall be in accordance with NFPA-13.

2.6 PIPE & FITTINGS (UNDERGROUND):

- A. Underground pipe shall be ductile iron, thickness Class 52 unless specified otherwise by local authorities or ANSI/AWWA C150/A21.50-81; 350 psi pressure rating; tar coated outside, cement mortar lined inside in accordance with ANSI/AWWA C104/A21.4-80. Full lengths of pipe shall be utilized to the greatest extent possible.
- B. Fittings for ductile iron pipe shall be 250 psi pressure rating in accordance with ANSI/AWWA C110-77, tar coated outside and cement lined inside in accordance with ANSI/AWWA C104/A21.4-80.
- C. Joints shall be push-on or mechanical type as per ANSI/AWWA C111/A21.11-80.

2.7 PIPE AND TUBING MATERIALS (INSIDE BUILDING):

- A. General: Refer to Part 3 Article "Pipe Applications" for identification of systems where the below specified pipe and fitting materials are used.
- B. Steel Pipe: ASTM A 53, A795 or A135, Schedule 40 or Schedule 10, U.S. manufacture, black steel pipe, plain ends.
- C. American Tube Company "Dyna-Thread-40" and "Dyna-Flow" and Allied Tube and Conduit Corporation "Super Flo" are acceptable to Schedule 40 pipe. Installation shall be per manufacturer's recommendations.
- D. Schedule 5 pipe shall not be allowed.
- E. The Corrosion Resistance Ratio of the pipe shall be 1.00 or greater. Documentation shall be presented with product submittal.
- F. Schedule 10 pipe shall only be allowed for pipe sizes 2-1/2inches and larger.
- G. Provide galvanized, schedule 40, piping system for preaction system and drain risers.

2.8 FITTINGS (INSIDE BUILDING):

- A. Cast-Iron Threaded fittings: ANSI B16.4, Class 125 standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

- B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 300, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1. Install steel pipe with threaded joints and fittings for 2inches and smaller and where shown on drawings.
- C. Steel Fittings: ASTM A234, seamless or welded, for welded joints.
- D. Grooved Mechanical Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47 Grade 32510 malleable iron; or ASTM A53, Type F or Types E or S.
- E. Grooved Mechanical Couplings: Consist of ductile or malleable iron housing, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure roll- grooved pipe and fittings. Grooved mechanical couplings including gaskets used on dry-pipe systems shall be listed for dry-pipe service.
- F. Grooved Mechanical Fittings and Couplings for the entire fire protection system shall be of the same manufacturer as submitted in shop drawing equipment review.
- G. Cast-Iron Threaded Flanges: ANSI B16.1, Class 250; raised ground face, bolt spot faced.
- H. Cast Bronze Flanges: ANSI B16.24, Class 300; raised ground face, bolt holes spot faced.
- I. Plain end, hooker type, or push-on fittings or couplings shall not be allowed.
- J. Bushings and reducing couplings shall not be allowed.
- K. UL listed and Factory Mutual approved segmentally welded fittings are acceptable. Friction loss and flow data shall accompany hydraulic calculations.

2.9 JOINING MATERIALS:

- A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.
- B. Gasket Materials: Thickness, materials and type suitable for fluid or gas to be handled, and design temperatures and pressures.

2.10 GENERAL DUTY VALVES:

- A. Gate Valves - 2 Inch and Smaller: Body and bonnet of cast bronze, 175 pound cold water working pressure - non-shock, threaded ends, solid wedge, outside screw and yoke, rising stem, screw-in bonnet, and malleable iron handwheel. Valves shall be capable of being repacked under pressure, with valve wide open.
- B. Gate Valves - 2-1/2 Inch and Larger: Iron body; bronze mounted, 175 pound cold water working pressure - non-shock. Valves shall have solid taper wedge; outside screw and yoke, rising stem; flanged bonnet, with body and bonnet conforming to ASTM A 126 Class B; replaceable bronze wedge facing rings; flanged ends; and a packing assembly consisting of a cast iron gland flange, brass gland, packing, bonnet, and bronze bonnet bushing. Valves shall be capable of being repacked under pressure, with valve wide open.
- C. Butterfly Valves: 2-1/2inches to 12inches, grooved, ductile iron body and disc ASTM-536, disc EPDM coated, listed and approved minimum 175 psi service, actuator, self-contained supervisory switch, weatherproof approved for indoor or outdoor use.

- D. Ball Valves: 1-1/2inches and smaller shall be threaded, forged brass construction, with teflon seats and blow out proof stem. Ball shall be full port with chrome plated ball.
 - E. Ball Valves: 2inches to 3inches shall be listed to 300 p.s.i. with optional internal tamper switch. Body shall be ductile iron with corrosion resistant coating. Ball shall be 316 stainless steel, standard port design.
 - F. Swing Check Valves: MSS SP-71; Class 175, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.
 - G. Double Check Valve Assembly: Double check valve assembly shall be UL listed for fire protection service and USC-CCCF approved. Installation arrangement shall be per manufacturer's recommendations.
 - H. Provide reduced pressure backflow preventer where required by authority having jurisdiction and/or water department having jurisdiction. See Part 2 Products under this Section for acceptable manufacturers and model number.
- 2.11 SPECIALTY VALVES:
- 2.12 BASIC METERS AND GAUGES:
- A. General: Provide meters and gauges complying with Division- 15 "Meters and Gauges", in accordance with the following listing
 - 1. Pressure gauges, 0-250 psi range.
- 2.13 ALARM DEVICE AND FIRE PROTECTION SPECIALTIES:
- A. General: Provide fire protection specialties, UL-listed, in accordance with the listing. Provide sizes and types which mate and match piping and equipment connections.
 - B. Water Flow Indicators: Vane type water flow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 volts DC; complete with factory-set field-adjustable retard element to prevent false signals, tamper-proof cover which sends a signal when cover is removed, and with activation time retarding capability set at 30 seconds. The setting shall be verified through the inspectors test prior to final inspection.
 - C. Supervisory Switches: Provide products recommended by manufacturer for use in service indicated. SPST, normally closed contacts, designed to signal valve in other than full open position.
 - D. Pressure Switch: Indicating low pressure trouble in sprinkler system.
 - E. Pressure switch: Indicating flow in sprinkler system.
 - F. Low Air Pressure Horn: Provide low air pressure horn as indicated.

2.14 AUTOMATIC SPRINKLERS:

- A. Sprinkler Heads: Fusible link or frangible bulb type, and style as indicated or required by the application. Unless otherwise indicated, provide heads with nominal 1/2 inch discharge orifice, for "ordinary" temperature range with a minimum temperature of 155 degrees F. Provide "intermediate" temperature heads in Electrical rooms, where required as noted in NFPA 13, and as required by the Authority having jurisdiction.
- B. Sprinkler Head Finishes: Provide heads with the following finishes:
 - 1. Upright, Pendent and Sidewall Styles: Factory brass, rough bronze finish for heads in unfinished spaces. Heads shall be stainless steel where installed exposed to acids, chemicals, or other corrosive fumes.
 - 2. Concealed Style: Rough brass, adjustable, with painted white cover plate in finished spaces. (GEM Models FR946 and F946 Clean Line Sprinklers are not acceptable.)
 - 3. Recessed Style: Bright chrome, with bright chrome escutcheon plate. GEM Models FR948 and F948 recessed sprinklers are not acceptable.
 - 4. See drawings for additional sprinkler type requirements.
- C. Sprinkler Head Cabinet and Wrench: Finished steel cabinet, suitable for wall mounting, with hinged cover and space for spare sprinkler heads plus sprinkler head wrench. Provide amounts of each style per NFPA-13. Locate head cabinet on shop drawing submittal.
- D. Plastic fire sprinkler escutcheons are not acceptable.

2.15 ROOF MANIFOLD:

- A. Provide [2] [3] way cast brass angle body, male outlets. Provide with [2] [3] hose angle valves (2-1/2inch), cast brass body, female inlet x male outlet, caps and chains, 300 psig rated. Manifold and valves shall have rough brass finish.

2.16 FIRE DEPARTMENT CONNECTIONS:

- A. Wall Type Siamese Connections: Polished chrome cast brass, 2-way flush wall type, with wall escutcheon and having National standard threads, for the connections size indicated, as specified in NFPA 1963. Each inlet shall have a clapper valve, and cap and chain. Unit shall have wall escutcheon of cast brass, finish to match connections, with words "Standpipe - Fire Dept. Connection" or "Auto Spkr. - Fire Dept. Connection" or "Auto Spkr. and Standpipe - Fire Department Connection" in raised letters. Contractor shall verify threads with local fire department.
- B. Sidewalk Siamese Connection: Polished Chrome plated cast brass, angle body, two way, siamese connection. Connection sizes shall be 4 inch outlet and two 2-1/2 inch inlets, having NH standard threads, for the connection size indicated, as specified in NFPA 1963. Each inlet shall have a clapper valve, and cap and chain. Provide 18 inch high chrome plated brass sleeve and chrome plated brass sidewalk plate, with words "Standpipe - Fire Dept. Connection" or "Auto Spkr. - Fire Dept. Connection" or "Auto Spkr. and Standpipe - Fire Department Connection" in raised letters.
- C. Fire department connections including location shall meet the approval of the fire department having jurisdiction.

2.17 INSPECTOR'S TEST AND DRAIN ASSEMBLY:

- A. Provide an alarm test module of a manufacturer listed in paragraph 2.2.
- B. Comply with NFPA-14, Section 5-11, for draining and testing of wet standpipe system.
- C. Test and drain piping shall be routed to exterior. Location shall meet Owner's approval.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine rough-in for fire hose valves and cabinets to verify actual locations of piping connections prior to installing cabinets.
- B. Examine walls for suitable conditions where cabinets are to be installed.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE APPLICATIONS:

- A. Install Schedule 40 steel pipe with threaded joints and fittings for 2 inch and smaller.
- B. Install Schedule 40 steel pipe with roll-grooved ends and grooved mechanical coupling or with threaded joints and fittings.
- C. Acceptable alternates to Schedule 40 pipe shall be installed per manufacturer's recommendations.

3.3 PIPING INSTALLATIONS:

- A. Provide a minimum 5feet-0inches cover for all underground pipe installations. Install in accordance with AWWA C600.
- B. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. So far as practical, install piping as indicated. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
 - 1. Deviations from approved "working plans" for sprinkler piping, require written approval of the authority having jurisdiction. Written approval shall be on file with the Engineer prior to deviating from the approved "working plans."
- C. Install sprinkler piping to provide for system drainage in accordance with NFPA 13.
- D. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes. Welded outlet branch pipe fittings are acceptable.
- E. Install unions in pipe 2 inch and smaller, adjacent to each valve. Unions are not required on flanged devices or in piping installations using grooved mechanical couplings.

- F. Install flanges or flange adapters on valves, apparatus, and equipment having 2-1/2 inch and larger connections.
 - G. For welded pipe, all cutouts (coupons) shall be removed prior to installation.
 - H. Hangers and Supports: Comply with the requirements of NFPA 13. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions, for rigid systems. Provide protection from damage where subject to earthquake in accordance with NFPA 13.
 - I. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.
 - J. Install mechanical sleeve seal at pipe penetrations in basement and foundation walls. Refer to Division 15 Section "Basic Piping Materials and Methods."
 - K. All piping penetrating walls to structure shall be sleeved and sealed per specification Section 15055.
 - L. Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.
 - M. Install pressure gauge on the riser or feed main at or near each test connection. Provide gauge with a connection not less than 1/4 inch and having a soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and where they will not be subject to freezing.
 - N. The fire line entry valves shall have monitoring electrical switches, the wiring from which shall be carried to the fire annunciating panel.
 - O. The fire protection contractor shall be responsible for the coordination of his installation with all other contractors. See Section 15010 for prioritized components.
 - P. Protect adjacent area where pipe cutting and threading takes place (e.g. floors, ceilings, walls, etc.).
 - Q. There shall be no fire sprinkler piping in electrical rooms (other than piping serving sprinklers directly in that room) or installed over any electrical panels.
 - R. Provide spring-loaded check valve at top of drain risers.
 - S. Install pressure gauges on city and system sides of fire entry valve assembly.
 - T. Install hangers straight and true and piping parallel to building lines.
- 3.4 PIPE JOINT CONSTRUCTION:
- A. Welded Joints: AWS D10.9, Level AR-3.
 - B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 2. Align threads at point of assembly.
 3. Apply appropriate tape or thread compound to the external pipe threads.
 4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.
 5. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
- C. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.
- D. Mechanical Grooved Joints: Roll grooves on pipe ends dimensionally compatible with the couplings.
- E. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.
- 3.5 VALVE INSTALLATIONS:
- A. General: Install fire protection specialty valves, fittings and specialties in accordance with the manufacturer's written instructions, NFPA 13 and the authority having jurisdiction.
- B. Gate Valves: Install electronically supervised-open indicating valves so located to control all sources of water supply except fire department and roof manifolds connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve. Refer to Division-15 Section "Mechanical Identification" for valve tags and signs.
- C. Valve at water main tap shall be underground gate valve with roadway box.
- D. Install approved check valve assembly [reduced pressure backflow preventer](#) in each water supply connection. Provide check valve and indicating valve (with tamper switch) on the discharge side of reduced pressure backflow preventers.
- E. Dry-Pipe Valves: Install in the vertical position, in proper direction of flow, in the main supply to the dry- pipe system. Install the basic trim set, priming chamber attachment and fill line attachment in accordance with the manufacturer's written instructions. During hydrostatic test of system piping at pressure in excess of 50 psi, position the clapper in latched wide open position or removed from valve, to prevent injury to the valve. Test valve for proper operation.
- F. Deluge Valves: Install in the vertical position, in proper direction of flow, in the main supply to the deluge system. Install the basic trim set in accordance with the manufacturer's written instructions. Connect system controls and test valve for proper operation.
- G. Hose Outlet Valves: Install 1-1/2 inch hose outlet valves at each standpipe outlet for hose connections for use by building occupants. Install 2-1/2 inch hose outlet valves at each standpipe outlet for hose connections for use by the fire department.

OR

- H. Hose Outlet Valves: Install 2-1/2 inch hose outlet valves with easily removable 2-1/2 to 1-1/2 inch reducing coupling at each standpipe outlet for hose connections.

3.6 SPRINKLER HEAD INSTALLATIONS:

- A. Any sprinkler heads with any paint on them shall be replaced. The sprinkler system shall then be hydrostatically tested again at the contractor's expense.
- B. Sprinkler heads shall be positioned so as to comply with NFPA-13 for any obstructions. This includes, but is not limited to, soffits, surface mounted lights and indirect lighting arrangements. The Fire Protection Contractor is responsible for identifying these obstructions and designing the system accordingly.
- C. Run piping concealed above heated furred ceilings and in joists to minimize obstructions. Expose only heads.
- D. Protect exposed sprinkler heads against mechanical injury with standard guards. Provide sprinkler head guards in all mechanical, electrical or storage rooms as well as exposed pendant heads which are installed less than 8feet-0inches A.F.F.
- E. Provide 1 inch diameter nipple and 1 inch x 1/2 inch reducing fitting for each upright head. (Excluding mechanical equipment rooms.)
- F. Provide heads in "pocketed" areas caused by exposed duct, piping or beams.
- G. Sprinkler head deflector distance from face of finished ceiling shall not exceed 4inches.
- H. Sprinkler heads shall be located in the center of all 2 foot x 2 foot ceiling tiles and quarter points, along the center line lengthwise of 2 foot x 4 foot ceiling tiles.
- I. Use proper tools to prevent damage during installations.
- J. Install sprinkler piping in a manner such that mechanical equipment, ceiling tiles or lights can be accessed and easily removed. The sprinkler piping shall be installed to provide a minimum of 6inches above the top of a finished ceiling.
- K. Minimum fire sprinkler head temperature rating for sprinklers in electrical rooms shall be 212 degrees F. Keep sprinklers as far from transformers and/or panels as spacing allows.

3.7 FIRE DEPARTMENT CONNECTION INSTALLATIONS:

- A. Install automatic drip valves at the check valve on the fire department connection to the mains. Route drain to exterior.
- B. Install mechanical sleeve seal at pipe penetration in outside walls.

3.8 ROOF MANIFOLD INSTALLATION:

- A. Install automatic drip valves between control valve and roof manifold outlets as to drain entire length of pipe. Route drain to Janitor's sink.
- B. Install mechanical sleeve seal at pipe penetration thru roof. Seal penetration water tight.

3.9 TEMPORARY CONSTRUCTION STANDPIPE SYSTEMS:

- A. Temporary construction of standpipe risers shall be provided, along with hose, nozzles and valves as appropriate and as required by the Authority Having Jurisdiction. The risers shall continue up thru each floor as the floors are erected. Standpipes shall be supplied through a temporary Siamese inlet at grade located and sized as directed by the Authority Having Jurisdiction. Access to the temporary Siamese inlet connection shall be kept clear and accessible at all times. It shall be the responsibility of the Contractor to insure this temporary fire protection supply be available at all times. All valves shall be properly adjusted for the maximum pressure setting allowable.
- B. The contractor shall be responsible for all design coordination and approval with the Authority Having Jurisdiction, construction and phasing of the temporary construction standpipe system.

3.10 INSTALLATION OF BASIC IDENTIFICATION:

- A. General: Install mechanical identification in accordance with Division-15 Basic Mechanical Materials and Methods section "Mechanical Identification".
- B. Install fire protection signs on piping in accordance with NFPA 13 and NFPA 14 requirements.

3.11 INSTALLATION OF METERS AND GAUGES:

- A. Install meters and gauges in accordance with Division-15 "Meters and Gauges".

3.12 FIELD QUALITY CONTROL:

- A. Flush, test and inspect sprinkler piping systems in accordance with NFPA 13, Standard for installation of sprinkler systems, Edition 1991 - Chapter 8.
- B. The fire sprinkler system shall not be connected to underground piping until the fire service main is tested and approved.
- C. The Fire Protection Contractor shall conduct and bear the costs of all necessary tests of the fire protection work, furnish all labor, power and equipment. All piping shall be tested with water as required, the tests witnessed by the authority having jurisdiction.
- D. Dry and preaction systems shall be both hydrostatically and pneumatically tested. Pneumatic test shall be in accordance with NFPA-13.
- E. The fire protection piping shall be tested under a hydrostatic pressure of not less than 200 psig, for a duration of not less than 2 hours.
- F. Replace piping system components which do not pass the test procedures specified, and retest repaired portion of the system at Fire Protection Contractor's expense.
- G. All piping tests (pneumatic and hydrostatic) shall be conducted prior to the application of any painting materials. This will prevent hidden leaks and/or repainting of repaired/altered piping.

3.13 SYSTEM CERTIFICATION:

- A. The Contractor shall provide the Owner with written certification prior to final inspection, that all new equipment:

1. Has been visually inspected and functionally tested as required by the Specifications.
2. Is installed entirely in accordance with the manufacturer's recommendations within the limitations of the system's UL listings and NFPA criteria.
3. Is in proper working order.

3.14 FINAL INSPECTION AND TESTING:

- A. The Contractor shall make arrangements with the Owner for final inspection and witnessing of the final acceptance tests. The Fire Protection Contractor, the Alarm System Contractor and the Owner will conduct the final inspection and witness the final acceptance test.
- B. All tests and inspections required by the referenced Codes and Standards, and the Owner shall be performed by the Contractor.
- C. The inspecting committee as referenced above will visit the job site to inspect the work and witness the final acceptance tests when they have been advised by the Contractor that the work is completed and ready for test. If the work is not complete or the test is unsatisfactory, the Contractor shall be responsible for the Consultant's extra time and expenses for re-inspection and witnessing the re-testing of the work. Such extra fees shall be deducted from payments by the Owner to the Contractor.
- D. After the system has been inspected and tested, a certificate, "Contractor's Material and Test Certificate Sprinkler System - Water Spray System," shall be provided by the contractor and shall be signed by him or his representative, the Owner's representative and by a representative of the fire department if appropriate. Sufficient copies shall be prepared to ensure the Engineer, Owner, all inspecting authorities and the contractor have a copy for their files. The Contractor shall prepare one (1) test report for each inspection performed whether successful or not.
- E. The signing of the certificate by the Owner's representative shall in no way prejudice any claim against the contractor for faulty material, poor workmanship, or failure to comply with inspecting authority's requirements or local ordinances.
- F. Contractor shall provide at least five (5) working days notice for all tests.
- G. All sprinkler supervisory initiating devices shall be functionally tested to verify proper operation.
- H. All supervisory functions of each initiating device shall be functionally tested.
- I. Receipt of all alarm and trouble signals, initiated during the course of the testing, shall be verified at the fire alarm control panel.

3.15 WORK BY OTHERS:

- A. Wiring of all water flow switches and tamper switches on valves to central alarm panel are by Division 16.

3.16 OPERATION AND MAINTENANCE MANUAL:

- A. The Contractor shall provide the Owner with a loose-leaf manual containing:

1. A detailed description of the systems.
 2. A detailed description of routine maintenance required or recommended or which would be provided under a maintenance contract including a maintenance schedule and detailed maintenance instructions for each type of device installed.
 3. One copy of NFPA-25.
 4. Manufacturers' data sheets and installation manuals/instructions for all equipment installed.
 5. A list of recommended spare parts.
 6. Service directory, listing the specific equipment items and where parts can be obtained, with name, address and telephone number.
 7. Full size sepias of the record drawings (stamped and signed per section 1.6).
 8. Hydraulic calculations (stamped and signed per section 1.6).
 9. Test certificates.
- B. Refer to [Division 1 and](#) Section 15010 "OPERATING AND MAINTENANCE" for additional requirements.
- C. Within 15 days of the completion of the work, six (6) copies of the manual shall be submitted for approval.

3.17 RECORD DRAWINGS:

- A. The Contractor shall provide and maintain on the site an up-to-date record set of approved shop drawing prints which shall be marked to show each and every change made to the sprinkler system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Owner without written instruction from the Owner in each case. This set of drawings shall be used only as a record set.
- B. Upon completion of the work, the record set of prints shall be used to prepare complete, accurate final record drawings reflecting any and all changes and deviations made to the sprinkler system.
- C. The Owner, at his option and at the Contractor's expense, may require revised hydraulic calculations depending on the extent and nature of field changes.
- D. The Record Drawings and Hydraulic Calculations shall have the signed stamp of a professional engineer registered in the [State of Colorado](#) certifying the Record Drawings and the Hydraulic Calculations accurately represent the completed fire protection system.
- E. Upon completion of the work, two sets of blue line record drawings shall be submitted to the Owner for review.
- F. Upon review of the blue line record drawings, before final approval, one (1) set of reproducible mylar record drawings and four (4) additional sets of blue line record drawings shall be delivered to the Owner.

3.18 GUARANTEE PERIOD:

- A. Guarantee: The Contractor shall guarantee all materials and workmanship for a period of one year beginning with the date of final acceptance by the Owner. The Contractor shall be responsible during the design, installation, testing and guarantee periods for any damage caused by him (or his subcontractors) or by defects in his (or his subcontractors') work, materials, or equipment.
- B. Emergency Service: During the installation and warranty period, the Contractor shall provide emergency repair service for the sprinkler system within four hours of a request by the Owner for such service. This service shall be provided on a 24 hour per day, seven days per week basis.

3.19 TRAINING:

- A. The Contractor shall conduct two (2) training sessions of four (4) hours each to familiarize the building personnel with the features, operation and maintenance of the sprinkler systems. Training sessions shall be scheduled by the Owner at a time mutually agreeable to the Contractor and the Owner.

3.20 WATER DAMAGE:

- A. The Fire Protection Contractor shall be responsible for any damage to the work of others, to building and property/ materials of others caused by leaks in automatic sprinkler equipment, unplugged or disconnected pipes or fittings, and shall pay for necessary replacement or repair of work or items so damaged during the installation, testing or guarantee periods of the automatic sprinkler work.

END OF SECTION 15300

SECTION 15411 - WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. This Section specifies the water distribution piping system, including potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building to a point 5 feet outside the building.
- B. Related Sections: The following Sections contain requirements that relate to this section.
 - 1. Refer to Division [2] [15] for trenching and backfilling materials and methods for underground piping installations.
 - 2. Refer to other Division 15 sections for piping materials; methods for sealing pipe penetrations through basement walls and fire and smoke barriers; thermometers, flow meters and pressure gauges; mechanical identification; plumbing pumps; and dielectric unions, strainers and pressure regulating valves.

1.2 DEFINITIONS:

- A. Water Distribution Piping: A pipe within the building or on the premises which conveys water from the water service pipe or meter to the points of usage.
- B. Water Service Piping: The pipe from the water main or other source of potable water supply to the water distributing system of the building served.
- C. Pipe Sizes used in this Specification are Nominal Pipe Size (NPS).

1.3 SUBMITTALS:

- A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.
- B. Provide data for each piping specialty and valve specified.
- C. Certification of Compliance with ASME and UL fabrication requirements.
- D. Test reports specified in Part 3 of this Section.
- E. Manufacturer and product data for lead free solder with material breakdown.
- F. Maintenance data for each piping specialty and valve specified for inclusion in operation and maintenance manual specified in Division 15.

1.4 QUALITY ASSURANCE:

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. ASME B 31.9 "Building Services Piping" for materials, products and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.
 - 2. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for Qualifications for Welding Processes and Operators.

3. Local Plumbing Code and Utility Department requirements.
 4. Local cross connection control manual.
- 1.5 DELIVERY, STORAGE AND HANDLING:
- A. Store pipe in a manner to prevent sagging and bending.
 - B. Cap ends of piping when being stored.
- 1.6 SEQUENCING AND SCHEDULING:
- A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad. Concrete, reinforcement, and formwork requirements are specified in Division 3.
 - B. Coordinate the installation of pipe sleeves for foundation wall penetrations.
- 1.7 EXTRA STOCK:
- A. Maintenance Stock: Furnish one valve key for each key operated wall hydrant, hose bibb, or faucet installed.

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS:
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Hose Bibbs and Faucets:
 - a. Chicago Faucet Co.
 - b. Nibco Inc.
 - c. Watts Regulator Co.
 - d. Crane
 - e. Woodford Mfg Co.
 2. Wall and Yard Hydrants:
 - a. Josam Mfg. Co.
 - b. Smith, (Jay R.) Mfg. Co.
 - c. Zurn
 - d. Woodford Mfg. Co.
 - e. Wade
 3. Backflow Preventers:
 - a. Febco Sales, Inc.; Subs. of Charles M. Bailey Co., Inc.
 - b. Wilkins
 - c. Watts Regulator Co.
 - d. Ames Company, Inc.
 - e. Conbraco

4. Relief Valves:
 - a. A.W. Cash Valve Mfg. Corp.
 - b. Watts Regulator Co.
 - c. Conbraco Industries, Inc.
 - d. Wilkins
 5. Shock Arresters - Piston Type:
 - a. Precision Plumbing Products
 - b. Sioux Chief
 - c. Watts Regulator
 6. Water Tempering Valves
 - a. Powers
 - b. Leonard
 - c. Rada
 7. Pressure Reducing Valves:
 - a. Watts Regulator Co.
 - b. Mueller
 - c. Conbraco Industries, Inc.
 - d. Wilkins
 8. Vacuum Breakers For Hose Connections:
 - a. Cash (A.W.) Valve Mfg. Corp.
 - b. Conbraco Industries, Inc.
 - c. Watts Regulator Co.
 9. Domestic Hot Water Expansion Tanks
 - a. Amtrol
 - b. State Industries
 - c. Taco
- 2.2 PIPE AND TUBE MATERIALS:
- A. General: Provide pipe material and pipe fittings complying with Division 15, Section 15055.
- 2.3 BASIC SUPPORTS AND ANCHORS:
- A. General: Provide supports and anchors complying with Division 15, Section 15140.
- 2.4 GENERAL DUTY VALVES:
- A. General: Provide valves complying with Division 15, Section 15100.
- 2.5 SPECIAL DUTY VALVES:
- A. Calibrated Balance Valve: Refer to Section 15135.

|

OR

- B. Balance Cocks: Ball valve complying with Section 15100, with memory stop device

2.6 PIPING SPECIALTIES:

- A. Shock Arrester - Piston Type: 60 psi precharge, sealed from system water with free sliding piston and EPDM O-rings. Suitable for up to 150 psi and 180 degrees F thread connections.

- B. Hose Bibbs

- 1. HB - [] [Unfinished and Equipment Rooms]: Rough bronze body, renewable composition disc, wheel handle, vacuum breaker, 3/4 inch NPT inlet, 3/4 inch hose outlet with vacuum breaker.

- Chicago Faucet No. 998

- Woodford No. 24 or Y24

- C. Wall Hydrants

- 1. WH-[] Flush with wall, non-freeze, box type, wall hydrant; all brass with nickel bronze box cover and frame, "T" handle loose key, key lock cover, integral vacuum breaker, self draining body and shank, 3/4 inch male hose thread outlet, 3/4 inch male or female I.P.S. thread inlet, renewable seat; shank length to extend thru primary exterior wall surface sufficient distance to prevent freezing.

- Woodford Model B65

- D. Backflow Preventers:

- 1. BFP-[] (Vacuum Breaker, Atmospheric): Atmospheric type, all brass, angle pattern with disc float that closes the atmospheric vent for temperatures up to 210 degrees F.; full size orifice for maximum flow; female thread inlet and outlet; rough brass chrome plated exterior finish; unit to be approved by National Sanitary Foundation.

- a. Watts No. 288

- E. Water Tempering Valves

- 1. WTV- [] Pressure Equalizing with Thermometer: Concealed type, 3-port, all bronze, pressure balancing mixing valve with integral angle check stops, maximum temperature limit stop, stainless steel balancing piston, chrome plated finished wall plate with hot and cold water marking; 1/2inch 3/4inch inlet and outlet pipe sizes and volume control. Unit to hold temperature steady and constant with pressure fluctuations up to 85 percent. Unit shall have integral or separate flush with wall, 3-color dial thermometer with scale from 70 degrees F to 130 degrees F and chrome plated trim ring for separate thermometer. Valve to deliver [] gpm.

- Powers P414.

- F. Thermostatic Mixing Valves

- 1. TMV-1: Exposed type, all bronze thermostatically controlled mixing valve with stainless steel piston, fail safe automatic shut-down if either hot or cold water pressure fails; union connection, rough chrome polished chrome finish. Valve to deliver [] gpm at

a pressure differential of [] psi; [] in. hot and cold water inlet pipe sizes, [] in. tempered water outlet pipe size.

Powers Series 430

2.7 DOMESTIC HOT WATER EXPANSION TANKS:

- A. Fabricated steel designed and constructed in accordance with ASME Section VIII, Division I.
- B. Heavy duty removable Butyl bladder.
- C. Working pressure of [100] [125] [150] psig.
- D. Maximum operating temperature of 240 degrees F.
- E. Tank liner of FDA approved materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:

- A. Refer to Section 15055, "Basic Piping Materials and Methods" for installation of piping.
- B. Install backflow preventers on plumbing lines where contamination of domestic water may occur and on boiler make-up lines, hose bibbs and flush valves.
- C. Install pressure reducing valves to limit maximum static pressure at plumbing fixtures to 65 [] psig.
- D. Install water hammer arresters in domestic water piping system on each set of flush valves and where hydrostatic shock pressures could occur.

3.3 HANGERS AND SUPPORTS:

- A. Refer to Section 15140, "Supports and Anchors" for supports and anchors.

3.4 PIPE AND TUBE JOINT CONSTRUCTION:

- A. Refer to Section 15055, "Basic Piping Materials and Methods" for pipe joints.

3.5 VALVE APPLICATIONS:

- A. General Duty Valve Applications: The drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
 - 1. Shut-off duty: Use gate, ball, and butterfly valves.
 - 2. Throttling duty: Use globe, ball, and butterfly valves.

3.6 INSTALLATION OF VALVES:

- A. Sectional Valves: Install sectional valves on each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections, and elsewhere as indicated. For sectional valves 2inch and smaller, use gate or ball valves; for sectional valves 2- 1/2inch and larger, use gate or butterfly valves.
- B. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, and on inlet of each plumbing fixture, and elsewhere as indicated. For shutoff valves 2inch and smaller, use gate or ball valves; for shutoff valves 2- 1/2inch and larger, use gate or butterfly valves.
- C. Drain Valves: Install drain valves on each plumbing equipment item, located to completely drain equipment for service or repair. Install drain valves at the base of each riser, at low points of horizontal runs, and elsewhere as required to completely drain distribution piping system. For drain valves 2inch and smaller, use gate or ball valves; for drain valves 2-1/2inch and larger, use gate or butterfly valves.
- D. Check Valves: Install non-slam spring loaded check valves on discharge side of each pump, and elsewhere as indicated. [See 15100 for valve application.](#)
- E. Balance Cocks: Install in each hot water recirculating loop, discharge side of each pump, and elsewhere as indicated.
- F. Hose Bibbs: Install on exposed piping where indicated, with vacuum breaker.
- G. Wall Hydrants: Install where indicated with vacuum breaker.

3.7 INSTALLATION OF PIPING SPECIALTIES:

- A. Install backflow preventers at each connection to mechanical equipment and systems, and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Pipe relief outlet thru air gap and without valves, to nearest floor drain.
- B. Install pressure regulating valves with inlet and outlet shutoff valves, and balance cock bypass. Install pressure gauge on valve outlet.
- C. Install shock arresters in locations shown on drawings and at all water connections to equipment with quick closing valves. Provide isolation valve. Install in accessible location. Provide access doors in accordance with architectural recommendations.

1. Units shall be sized in accordance with the following schedule.

Drawing Designation	Fixture Unit Rating	P.D.I. Size
SA-1	1-11	A
SA-2	12-32	B
SA-3	33-60	C

SA-4	61-113	D
SA-5	114-154	E
SA-6	155-330	F

3.8 INSTALLATION OF DOMESTIC HOT WATER EXPANSION TANKS:

- A. Install expansion tanks in compliance with the plumbing code and the authority having jurisdiction.
- B. Locate tanks in the same room as the water heaters on storage tanks on the cold water supply line as close to the water heater or storage tank as possible. Installation is to be between the water heater or storage tank and backflow preventer, check valve, pressure reducing valve and/or meter.
- C. Provide independent support for in-line mounted tanks.
- D. Precharge tank to minimum static water pressure at the tank location.

3.9 EQUIPMENT CONNECTIONS:

- A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts to fixtures of sizes indicated, but in no case smaller than required by Plumbing Code.
- B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection, provide drain valve on drain connection. Provide back-flow preventor as shown as required. For connections 2-1/2inch and larger, use flanges instead of unions.

3.10 FIELD QUALITY CONTROL:

- A. Inspections: Inspect water distribution piping as follows:
 - 1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.
 - 2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 48 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.
 - a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.
 - 3. Reinspections: Whenever the plumbing official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the plumbing official.
 - 4. Reports: Prepare inspection reports, signed by the plumbing official.

B. Test water distribution piping as follows:

1. Refer to Section 15055 "Basic Piping Materials and Methods" for pipe test.

3.11 ADJUSTING AND CLEANING:

A. Clean and disinfect water distribution piping as follows:

1. Purge all new water distribution piping systems and parts of existing systems, which have been altered, extended, or repaired prior to use.
2. Use the purging and disinfecting procedure prescribed by the authority having jurisdiction, or in case a method is not prescribed by that authority, the procedure described in either AWWA C651, or AWWA C652, or as described below:
 - a. Flush the piping system with clean, potable water until dirty water does not appear at the points of outlet.
 - b. Fill the system or part thereof, with a water/chlorine solution containing at least 50 parts per million of chlorine. Isolate (valve off) the system, or part thereof, and allow to stand for 24 hours.
 - c. Drain the system, or part thereof, of the previous solution, and refill with a water/chlorine solution containing at least 200 parts per million of chlorine and isolate and allow to stand for 3 hours.
 - d. Following the allowed standing time, flush the system with clean potable water until chlorine does not remain in the water coming for the system.
 - e. Submit water samples in sterile bottles to the authority having jurisdiction. Repeat the procedure if the biological examination made by the authority shows evidence of contamination.

B. Prepare reports for all purging and disinfecting activities.

3.12 COMMISSIONING:

A. Fill the system.

B. Check compression tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close drain, valves, hydrants, and sill cocks.
2. Remove and clean strainers.
3. Check pump for proper direction of rotation. Correct improper wiring.
4. Lubricate pump motors and bearings.

END OF SECTION 15411

SECTION 15420 - DRAINAGE AND VENT SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. This Section specifies building sanitary drainage, storm drainage and vent piping systems, including drains and drainage specialties.
- B. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Refer to Division 2/15 sections for trenching and backfilling materials and methods for underground piping installations; not work of this section.
 - 2. Refer to Division 2/15 Section for storm water drainage piping beginning from 5feet-0inches outside the building; sanitary drainage piping beginning from 5feet-0inches outside the building; foundation drain piping; not work of this section.
 - 3. Refer to other Division 15 sections for piping materials and methods, sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers; mechanical identification.

1.2 DEFINITIONS:

- A. Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer to a point 5feet-0inches outside the building wall.
- B. Building Sewer: That part of the horizontal piping of a drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.
- C. Drainage System: Includes all the piping within a public or private premises which conveys sewage, rain water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.
- D. Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.
- E. See legend on drawings for additional information.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data for all plumbing items including model clearly indicated; operating weights; furnished specialties and accessories; and installation instructions.
- B. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, required clearances, and methods of assembly of components.
- C. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 15.

- D. Maintenance Data: Submit maintenance data and parts lists for each type of drain, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data and shop drawings in maintenance manual; in accordance with requirements of Division 15.

1.4 QUALITY ASSURANCE:

- A. Regulatory Requirements: Comply with the provisions of the following:
 - 1. Plumbing Code Compliance: Comply with applicable portions of Local Plumbing Code.
 - 2. ANSI Compliance: Comply with applicable ANSI standards pertaining to materials, products, and installation of soil and waste systems.
 - 3. ASSE Compliance: Comply with applicable ASSE standards pertaining to materials, products, and installation of soil and waste systems.
 - 4. PDI Compliance: Comply with applicable PDI standards pertaining to products and installation of soil and waste systems.
 - 5. PVC, PP and ABS Pipe: Only Contractor's personnel which have received training in the installation of this material and meet the manufacturer's qualifications shall do the assembly of such material.

1.5 SEQUENCING AND SCHEDULING:

- A. Coordinate the installation of roof drains, flashing, and roof penetrations.
- B. Coordinate flashing materials installation of roofing, waterproofing, and adjoining substrate work.
- C. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.
- D. Coordinate with installation of sanitary and storm sewer systems as necessary to interface building drains with drainage piping systems.
- E. Coordinate all penetrations with Structural Engineer.
- F. Coordinate all installations with other trades.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide drainage and vent systems from one of the following:
 - 1. Drainage Piping Specialties, including backwater valves, expansion joints, drains, cleanouts, trap primers, flashing flange and vent flashing sleeve:
 - a. Josam Mfg. Co.
 - b. Smith (Jay R) Mfg. Co.
 - c. Tyler Pipe; Subs. of Tyler Corp.
 - d. Zurn Industries Inc; Hydromechanics Div.
 - e. Wade

- f. Woodford
 - g. Precision Plumbing Products
 - 2. Non-Metallic Trench Drains:
 - a. ACO Drain Inc.
 - b. Quazite Corp.
 - 3. Precast Concrete Basins and Manholes:
 - a. Arco
 - b. Copeland
 - c. Amcor
- 2.2 SANITARY AND STORM DRAINAGE, VENT AND SUBSURFACE DRAINAGE PIPE AND FITTINGS:
 - A. General: Provide piping and pipe fittings complying with Division 15, Section 15055.
- 2.3 BASIC SUPPORTS AND ANCHORS:
 - A. General: Provide supports and anchors complying with Division 15, Section 15140.
- 2.4 DRAINAGE PIPING SPECIALTIES:
 - A. Backwater Valves: Valve assembly shall be bronze fitted cast-iron, with bolted cover. Flapper shall provide a maximum 1/4inch clearance between flapper and seat for air circulation. Valve ends shall suit piping.

Jay R. Smith Fig. 7012
 - B. Trap Primers (For equipment room floor drains and as otherwise noted): Bronze body valve with automatic vacuum breaker, with 1/2inch connections matching piping system. Complying with ASSE 1018.
 - 1. Valves shall be easily adjusted to high or low pressure and shall be automatically activated whenever any faucet is opened in the building, causing a pressure drop.
 - 2. Connections: Inlet 1/2inch male NPT; outlet 1/2inch female NPT.
 - 3. Valves shall be "Prime-Rite" Trap Primer Valve as manufactured by Precision Plumbing Products, Inc., or approved equal.
 - 4. When more than one (1) trap is to be primed, provide one or more distribution units as required by the manufacturer.
 - C. Expansion Joints: Cast-iron body with adjustable bronze sleeve, bronze bolts with wing nuts.
 - D. Flashing Flanges: Cast-iron watertight stack or wall sleeve with membrane flashing ring. Provide underdeck clamp and sleeve length as required.
 - E. Vent Flashing Sleeves: Cast-iron caulking type roof coupling for cast-iron stacks, cast-iron threaded type roof coupling for steel stacks, and cast-bronze stack flashing sleeve for copper tubing.

2.5 CLEANOUTS:

- A. Cleanout Plugs: Cast brass, threads complying with ANSI B2.1, and local plumbing code.
- B. Floor Cleanout: Round, cast iron body with recessed bronze closure plug; scoriated polished bronze frame and cover plate.
- C. Wall Cleanout: Cleanout tee with raised head brass plug tapped for 1/4-20 thread; flat style chrome plated wall cover plate with holes for 1/4inch bolt; 1/4-20 threaded bolt with chrome plated flat head.
- D. Surface Cleanout: Cast iron body ferrule with raised head brass plug. Medium duty cast iron manhole cover and ring 12inch diameter to be set in concrete pad, Neenah No. R-1791-A.
- E. Line Cleanout: Cast iron tapped cleanout ferrule with raised head brass plug.

2.6 FLOOR DRAINS:

- A. Floor drain type designations and sizes are indicated on Drawings.

1. FD-1 Toilet Rooms and Finished Areas

Round cast iron body with flashing collar and cast iron ring, 6 inch round nickel bronze adjustable strainer head with secured square hole grate, bottom waste outlet.

Jay R. Smith Fig. 2005-A

2. FD-2 Boiler and Mechanical Rooms

Round cast iron, light duty, shallow body drain with flashing collar and cast iron ring, 8inches round tractor type non-tilt slotted grate and sediment bucket, bottom waste outlet.

Jay R. Smith Fig. 2220

2.7 SANITARY SEWER MANHOLES:

- A. Manholes shall be constructed from pre-cast concrete sections as shown with heavy duty cast iron traffic cover and rim. See mechanical plans for invert elevations of inlet and outlet piping; see detail on mechanical plans.
- B. The manhole base shall be constructed from heavy density concrete poured at least 48 hours prior to setting the precast sections.
- C. Flow channels that provide smooth flow and maintain the sewer grade shall be formed in cement mortar on the base. The channels shall be troweled smooth.
- D. The bottom manhole section shall be set in a full mortar base (21inches thick) while the base is still moist. All succeeding sections shall be joined in a similar manner, and all holes and imperfections shall be filled with cement mortar.
- E. The manhole cover shall be installed with cast iron receiving frame and adjustable rings so that it is flush with pavement or grade. The cover shall be suitable for A.A.S.H.O. H-20 wheel loading.

F. See detail on mechanical plans.

2.8 ROOF DRAINS:

A. Roof drain type designations and sizes are indicated on Drawings.

1. RD-1

Cast iron body with sump, removable cast iron vandal-proof dome strainer, cast iron flashing flange and cast iron ring with integral gravel stop, underdeck clamp.

Jay R. Smith Fig. 1010

2. OFD-1 Overflow Drain

Cast iron body with sump, removable cast iron vandal-proof dome strainer, cast iron flashing flange and cast iron clamp with integral gravel stop, cast iron underdeck clamp, standpipe with inlet flow line two (2) inches above the low point of the roof under dome strainer.

Jay R. Smith Fig. 1070

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
- B. Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.
- C. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- D. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.
- E. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.
- F. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.
- G. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into account many design considerations. So far as practical, install piping as indicated.

- B. Install overflow roof drains with the inlet flow line located a maximum 2 inches above the lowest point of roof.
- C. All floor drains are to be provided with P-trap the same size as the floor drain unless otherwise noted on mechanical drawings.
- D. Provide flashing membrane for all floor drains in structure above slab on grade level; see flashing detail on mechanical drawings.
- E. Lubricate cleanout plugs with mixture of graphite and linseed oil. Prior to building turnover remove cleanout plugs, relubricate and reinstall using only enough force to ensure permanent leakproof joint.
- F. Provide flashing for all floor drains above grade. Make watertight with Chloraloy 240 underslab moisture vapor barrier as manufactured by the Nobel Co. of Grand Haven, Michigan. Flashing shall extend at least 24 inches from drain rim into floor membrane or on structural floor. Fasten flashing to drain clamp device and make watertight, durable joint. Provide flashing collar extension with all drains and cleanouts installed above grade.

3.3 HANGERS AND SUPPORTS:

- A. General: Refer to Section 15140 for supports and anchors.

3.4 INSTALLATION OF PIPING SPECIALTIES:

- A. Install backwater valves in sanitary building drain piping as indicated, and as required by the plumbing code. For interior installation, provide minimum 13 inches dia. cleanout cover flush to floor centered over backwater valve cover and of adequate size to remove valve cover for service.
- B. Install expansion joints on vertical risers as indicated, and as required by the installation and plumbing code. See plans for detail.
- C. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and extend cleanouts to floor or wall above. Line cleanouts not acceptable.
 - 1. As required by plumbing code;
 - 2. At each change in direction of piping greater than 45 degrees below slab;
 - 3. At minimum intervals of 50 feet;
 - 4. At base of each vertical soil or waste stack;
 - 5. At sinks and urinals on grade;
 - 6. At egress of building (surface cleanout).
 - 7. At each water closet or toilet group.
- D. Cleanouts Covers: Install floor and wall cleanout covers, types as indicated, and in accessible locations.
- E. Flashing Flanges: Install flashing flange and clamping device with each stack and cleanout passing through waterproof membranes.
- F. Vent Flashing Sleeves: Install on stacks passing through roof, secure over stack flashing in accordance with manufacturer's instructions.

3.5 PIPE AND TUBE JOINT CONSTRUCTION:

- A. Install pipes and pipe joints in accordance with section 15055.

3.6 INSTALLATION OF FLOOR DRAINS:

- A. Install floor drains in accordance with manufacturer's written instructions and in locations indicated.
- B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.
- C. Trap all drains connected to the sanitary sewer with minimum trap size that of drain connected.
- D. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.
- E. Position drains so that they are accessible and easy to maintain.

3.7 INSTALLATION OF ROOF DRAINS:

- A. Install roof drains at low points of roof areas, in accordance with the roof membrane manufacturer's installation instructions.
- B. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.
- C. Position roof drains so that they are accessible and easy to maintain.

3.8 SERVICE CONNECTIONS:

- A. Provide new sanitary/storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
- B. Provide all necessary piping and connections from building drain/storm drain system to connection with city sewer systems in location shown on mechanical site plan.

3.9 CONNECTIONS:

- A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the plumbing code.
- B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.10 FIELD QUALITY CONTROL:

- A. Inspections:
 - 1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 48 hours prior to the time such inspection must be made. Perform tests specified in Section 15055 in the presence of the plumbing official.
 - a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection to observe the tests specified and to insure compliance with the requirements of the plumbing code.
 3. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspection.
 4. Reports: Prepare inspection reports, signed by the plumbing official.
- B. Piping System Test: Test drainage and vent system in accordance with the procedures of the authority having jurisdiction, or in the absence of a published procedure, as follows, and as described in Section 15055.
- 3.11 ADJUSTING AND CLEANING:
- A. Clean interior of piping. Remove dirt and debris as work progresses.
 - B. Clean drain strainers, domes, and traps. Remove dirt and debris.
- 3.12 PROTECTION:
- A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.
 - B. Place plugs in ends of uncompleted piping at end of day or whenever work stops. Piping shall not be left open ended during construction.

END OF SECTION 15420

SECTION 15440 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of plumbing fixtures work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. This Section specifies plumbing fixtures and trim. The types of fixtures specified included but are not limited to the following:
 - 1. Lavatories (including wheelchair type);
 - 2. Sinks;
 - 3. Water Closets;
 - 4. Urinals;
 - 5. Mop Sink Basins;
 - 6. Wall Mounted Water Coolers (including wheelchair type);
 - 7. Faucets;
 - 8. Flush Valves;
 - 9. Fixture Supports (including wheelchair type);
 - 10. Toilet Seats;
 - 11. Fittings, Trim, and Accessories;

1.2 QUALITY ASSURANCE:

- A. Codes and Standards:
 - 1. ASHRAE Standard 18: "Method of Testing for Rating Drinking Water Coolers with Self-Contained Mechanical Refrigeration Systems."
 - 2. ARI Standard 1010: "Drinking-Fountains and Self- Contained Mechanically-Refrigerated Drinking-Water Coolers"
 - 3. ANSI Standard A117.1: "Specifications for Making Buildings and Facilities Accessible To and Usable By Physically Handicapped People."
 - 4. Public Law 90-480: "Architectural Barriers Act of 1968."
 - 5. UL Standard 399: "Drinking-Water Coolers."
 - 6. Public Law 101-336: "Americans With Disabilities Act."
 - 7. NSF Standard 61: "Drinking Water Components."
 - 8. Energy Conservation Act - 1992: "Energy Conservation Standards."
- B. Where fixtures are specified as handicapped, it shall be the sole responsibility for all manufacturers and/or suppliers to provide plumbing fixtures and related trim which meet or exceed the ADA requirements.

1.3 SUBMITTALS:

- A. Product Data: Submit Product Data and installation instructions for each fixture, faucet, specialties, accessories, and trim specified; clearly indicate rated capacities of selected models of water coolers.
 - B. Shop Drawings: Submit rough-in drawings with brand names on each sheet and item. Detail dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages. Coordinate requirements with Architectural Woodwork shop drawings specified in Division 6 for fixtures installed in countertops and cabinets. Furnish templates for use in woodwork shop.
 - C. Wiring Diagrams: Submit manufacturer's electrical requirements and wiring diagrams for power supply to units. Clearly differentiate between portions of wiring that are factory installed and field installed portions.
 - D. Color Charts: Submit manufacturer's standard color charts for cabinet finishes and fixture colors.
 - E. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured plumbing fixtures, valves and trim. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.
 - F. Submit certification of compliance with specified ANSI, UL, and ASHRAE Standards.
 - G. Submit certification of compliance with performance verification requirements specified in this Section.
- 1.4 DELIVERY, STORAGE, AND HANDLING:
- A. Store fixtures where environmental conditions are uniformly maintained within the manufacturer's recommend temperatures to prevent damage.
 - B. Store fixtures and trim in the manufacturer's original shipping containers. Do not stack containers or store in such a manner that may cause damage to the fixture on trim.
- 1.5 SEQUENCE AND SCHEDULING:
- A. Schedule rough-in installations with the installation of other building components.
- 1.6 MAINTENANCE:
- A. Extra Stock:
 - 1. Furnish special wrenches and other devices necessary for servicing plumbing fixtures and trim to Owner with receipt in a quantity of one device for each 10 fixtures, minimum of one wrench and one device.
 - 2. For each type of faucet, furnish faucet repair kits complete with all necessary washers, springs, pins, retainers, packings, O-rings, sleeves, and seats in a quantity of 1 kit for each 40 faucets, minimum one repair kit per faucet type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Lavatories, Sinks, Water Closets, Urinals:
 - a. American Standard U.S. Plumbing Products.
 - b. Crane Co.
 - c. Kohler Co.
 - d. Eljer

2. Stainless Steel Sinks:
 - a. Elkay Mfg. Co.
 - b. Just Mfg. Co.
 - c. Moen; Div. of Stanadyne.

3. Faucets:
 - a. American Standard; U.S. Plumbing Products.
 - b. Chicago Faucet Co.
 - c. Delta Faucet Co./Cambridge Brass; Div. of Masco Corp.
 - d. Elkay Mfg. Co.
 - e. Kohler Co.
 - f. T & S Brass
 - g. Eljer
 - h. Bradley

4. Flush Valves:
 - a. Coyne & Delany Co.
 - b. Sloan Valve Co.
 - c. Zurn Industries, Inc.

5. Water Closet Seats:
 - a. Bemis Mfg. Co.
 - b. Beneke Corp.
 - c. Church Seats
 - d. Olsonite Corp.; Olsonite Seats.

6. Water Coolers:
 - a. Elkay Mfg. Co.
 - b. Halsey Taylor Div.; Household International Co.
 - c. Haws Drinking Faucet Co.
 - d. Sunroc Corp.
 - e. Oasis

7. Fixture Supports:
 - a. Josam Mfg. Co.
 - b. Kohler Co.
 - c. Tyler Pipe.
 - d. J.R. Smith.
 - e. Zurn.

8. Mop Service Basins:
 - a. Oberon
 - b. Fiat

9. ADA Sink/Lavatory Pipe Insulation:
 - a. True Bro
 - b. McGuire

2.2 FIXTURES:

A. Water Closets

- | 1. WC-[] Water Closet

Vitreous china, wall mounted, siphon jet action, elongated bowl, 1-1/2inches top inlet spud, 2-1/4inches minimum passageway, 1.6 GPF. Provide support as specified in the following articles.

American Standard No. 2257.103 or equivalent by approved manufacturer.
Kohler No. K-4330

Flush Valve Type: A
Seat Type: A

- | 2. WC-[] Water Closet - ADA Accessible

Vitreous china, wall mounted 17inches to 19inches from finished floor to top of seat, siphon jet action, elongated bowl, 1-1/2inch top inlet spud, 2-1/4inches minimum passageway, 1.6 GPF. Provide support as specified in the following articles.

American Standard No. 2257.103 or equivalent by approved manufacturer.
Kohler No. K-4330

Flush Valve Type: A
Seat Type: A

- | 3. WC-[] Water Closet

Vitreous china, floor mounted, siphon jet action, elongated bowl, 1-1/2inches top inlet spud, and 2-1/4inches minimum passageway, 1.6 GPF.

American Standard No. 2234.015 or equivalent by approved manufacturer.
Kohler No. K-4350

Flush Valve Type: A
Seat Type: A

- | 4. WC-[] Water Closet - ADA Accessible

Vitreous china, floor mounted, 17inches to 19inches from finished floor to top of seat, floor mounted, siphon jet action, elongated bowl, 1-1/2inches top inlet spud, 2-1/4inches passageway, 1.6 GPF.

American Standard No. 3043.102 or equivalent by approved manufacturer.

Kohler No. K-4368

Flush Valve Type: A

Seat Type: A

5. WC - [] Water Closet - Pressure Assist

Vitreous china, floor mounted, siphon jet action, elongated bowl, close-coupled tank, pressure assist, tank covering locking device, 2inch passageway, 2 bolt caps, backflow preventer water control with volume regulator, flush valve, triplever, 1.6 GPF.

American Standard No. 2292.100 or equivalent by approved manufacturer.

Kohler No. K-3458

Seat Type: A

6. WC - [] Water Closet - ADA Accessible - Pressure Assist

Vitreous china, 17inches to 19inches from finished floor to top of seat, floor mounted, siphon jet action, elongated bowl, close-coupled tank, pressure assist, tank cover locking device, 2inch passageway, 2 bolt caps, backflow preventer water control with valve regulator, flush valve, triplever located on wide side of stall, 1.6 GPF.

American Standard No. 2168.100 or equivalent by approved manufacturer.

Kohler No. K-3544

Seat Type: A

B. Urinals

1. UR-[] - ADA Accessible

Vitreous china, wall mounted, 1.0 GPF, siphon jet action, 3/4inch top inlet spud, flushing rim, extended stall sides, 2inch outlet connection, open trap-way with visible water surface, and back and sidewall wash. Provide support as specified in the following articles.

American Standard No. 6561.017 or equivalent by approved manufacturer.

Kohler No. K-4989-T

Flush Valve Type: C

2. UR-[] - ADA Accessible

Vitreous china, 1.0 GPF , 14inches front to wall, 17inches from finished floor to rim maximum, wall mounted with siphon jet action, 3/4inch top inlet spud, 2inch outlet connection, and wall hangers. Provide support as specified in the following articles.

American Standard No. 6541.132 or equivalent by approved manufacturer.

Kohler No. K-5016-T

Flush Valve Type: C

C. Lavatories

1. L-[]

Vitreous china, 19-1/8inch diameter round, self-rimming countertop lavatory with front overflow, fitting ledge, template and sealant. Faucet holes on 4"/8" centers.

American Standard No. 0490.011 8inch centers or equivalent by approved manufacturer.
Kohler No. K-2202-8

American Standard No. 0491.019 4inch centers or equivalent by approved manufacturer.
Kohler No. K-2022-4

Lavatory Trim Type:

2. L-

Vitreous china, 20-1/2inches x 18-1/4inches, wall mounted lavatory with front overflow, integral back and made for concealed arm supports. Faucet holes on 4"/8" centers.

American Standard No. 0355.012 4inch centers or equivalent by approved manufacturer.
Kohler No. K-2032

American Standard No. 0356.015 8inch centers or equivalent by approved manufacturer.
Kohler No. K-2030

Lavatory Trim Type:
Support Type: B

3. L-

Vitreous china, 18inches x 15-7/8inches, wall mounted lavatory with front overflow, soap depression, integral back and made for concealed arm supports. Faucet holes on 4"/8" centers.

American Standard No. 0373.050 4inch centers or equivalent by approved manufacturer.
Kohler No. K-2027

American Standard No. 0372.052 8inch centers or equivalent by approved manufacturer.
Kohler No. K-2023

Lavatory Trim Type:
Support Type: B

4. L-

Vitreous china, 20-1/2inches x 17-1/2inches self-rimming rectangular countertop lavatory with front overflow, soap depressions, template and sealant. Faucet holes on 4"/8" centers.

American Standard No. 0498.800 8inch centers or equivalent by approved manufacturer.
Kohler No. K-2187

American Standard No. 0498.400 4inch centers or equivalent by approved manufacturer.
Kohler No. K-2185

Lavatory Trim Type:

5. L-

Vitreous china, 20inches x 17inches self-rimming oval countertop lavatory with front overflow, fitting ledge, template and sealant. Faucet holes on 4"/8" centers.

American Standard No. 0475.020 8inch centers or equivalent by approved manufacturer.
Kohler No. K-2196-8

American Standard No. 0476.028 4inch centers or equivalent by approved manufacturer.
Kohler No. K-2196-4

Lavatory Trim Type:

6. L- Wheelchair Lavatory - ADA Accessible

Vitreous china, 27inches x 20inches, wall mounted wheelchair lavatory with front overflow and made for concealed arm support. Faucet holes on 4"/12" centers.

American Standard No. 9141.011 4inch centers or equivalent by approved manufacturer.
Kohler No. K-1263

American Standard No. 9140.013 12inch centers or equivalent by approved manufacturer.
Kohler No. K-12634

Lavatory Trim Type: 7 12inch centers
Support Type: B

D. Sinks

1. S- Single Compartment

18 gauge type 302 or 304 stainless steel 19" x 21" O.D., compartment size 14" x 18" x 7-1/2"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. SL-1921-A-GR or equivalent by approved manufacturer.

Sink Trim Type:

2. S- Single Compartment

gauge Type 302 or 304/316 stainless steel " x " O.D., compartment size " x " x "; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

3. S- Single Compartment

gauge Type 302 or 304/316 stainless steel " x " O.D., compartment size " x " x "; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

4. S- Single Compartment

gauge Type 302 or 304/316 stainless steel ___" x ___" O.D., compartment size ___" x ___" x ___"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

5. S- Single Compartment

gauge Type 302 or 304/316 stainless steel ___" x ___" O.D., compartment size ___" x ___" x ___"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

6. S- Single Compartment

gauge Type 302 or 304/316 stainless steel ___" x ___" O.D., compartment size ___" x ___" x ___"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

7. S- Single Compartment

gauge Type 302 or 304/316 stainless steel ___" x ___" O.D., compartment size ___" x ___" x ___"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

8. S- Single Compartment

gauge Type 302 or 304/316 stainless steel ___" x ___" O.D., compartment size ___" x ___" x ___"; self-rimming ledge back, thoroughly sound deadened, with 1/2/3-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

9. S- Double Compartment

18 gauge type 302 or 304 stainless steel 19" x 33" O.D. with (2) compartments at 14" x 14" x 7-1/2" each; self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. DL-1933-A-GR or equivalent by approved manufacturer.

Sink Trim Type:

10. S- Double Compartment

gauge type 302 or 304/316 stainless steel " x " O.D., (2) compartments at " x " x " each, self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

11. S- Double Compartment

gauge type 302 or 304/316 stainless steel " x " O.D., (2) compartments at " x " x " each, self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

12. S- Double Compartment

gauge type 302 or 304/316 stainless steel " x " O.D., (2) compartments at " x " x " each, self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

13. S- Double Compartment

gauge type 302 or 304/316 stainless steel " x " O.D., (2) compartments at " x " x " each, self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. or equivalent by approved manufacturer.

Sink Trim Type:

14. S- Double Compartment Unequal Compartments

[] gauge type 302 or 304/316 stainless steel " x " O.D., (2) compartments. Left compartment at " x " x ", Right compartment at " x " x " self-rimming ledge-back, thoroughly sound deadened with 1/2/3/4-hole punching for faucet.

Just No. [] or equivalent by approved manufacturer.

Sink Trim Type: []

15. MSB-[] Mop Service Basin

Precast terrazzo 24" x 24" x 12" deep, O.D., service basin with 3inch integrally cast brass or stainless steel drain with removable stainless steel or nickel bronze strainer. Provide stainless steel guards on all sides.

Provide and install 12inch high, stainless steel splash panels to protect walls above rim.

Fiat Model No. TSB-100 or equivalent by approved manufacturer.

Sink Trim Type: 9

16. MSB-[] Mop Service Basin - Corner Type

Precast Terrazzo 24" x 24" x 12" deep front drop corner type mop service basin with 3inch integrally cast brass or stainless steel drain with removable stainless steel or nickel bronze strainer. Provide stainless steel guards on threshold.

Provide and install stainless steel splash panels to protect walls above basin rim.

Fiat Model No. TSBC-1610 or equivalent by approved manufacturer.

Sink Trim Type 9

2.3 WATER COOLERS:

A. EWC-[] Wall Mounted Water Coolers /Barrier Free:

1. Units shall be factory assembled and tested, listed and labeled in compliance with UL Standard 399, and have capacities rated in accordance with ASHRAE Standard 18, and ARI Standard 1010.
2. Cabinet: 25-7/8" x 17" x 18" deep surface mounted, heavy gauge, welded steel cabinet, with removable vinyl front panel and hanger bracket for wall mounting. Cabinet finish and vinyl color as selected by the Architect/Engineer. Standard color is a brushed sterling.
3. Top: Deep basin, anti-splash, smoothly contoured stainless steel with raised bubbler mount, chrome plated brass strainer, and 1-1/4inch tailpiece.
4. Bubbler and Valve: Chrome plated brass, automatic stream control, push-button valve with bubbler designed to provide uniform stream without spurting. Push bars shall not be plastic.
5. Refrigeration System: Refrigerant R-134A, hermetically sealed, capillary tube. All joints lead free silver soldered.

- a. Compressor: Hermetically sealed, with automatic reset overload protection.
 - b. Condenser: Air-cooled
 - c. Cooling Unit: Tube type, self-cleaning, continuous coil of seamless copper.
 - d. Temperature Control: Thermostat with adjustable range of 45 degrees F to 55 degrees F, factory set at 50 degrees F.
6. Electrical Characteristics: 120 volts, 60 Hz, 1/6 HP, 3.0 amperes, provide 3-prong power lead-in cord.
 7. Capacity: 8.5 GPH of 50 degrees F. water, with ambient temperature of 90 degrees F., and 80 degrees F. entering water temperature.
 8. Connections: Provide Trap, and supply and stop as specified in the Articles below.
 - a. Haws Model No. HWBFA8
 - b. Haws Model No. NWBFA8ET (7.5 second timed water flow)
 9. Provide 4inch air space on both sides of unit for cooling air flow.
 10. Mounting: Tubular steel supports bolted to floor.
- B. EWC-[] Wall Mounted Barrier Free Water Cooler:
1. Units shall be factory assembled and tested, listed and labeled in compliance with UL Standard 399, and have capacities rated in accordance with ASHRAE Standard 18, and ARI Standard 1010.
 2. Receptor: Heavy gauge, stainless steel, with No. 4 finish on the outside, raised bubbler mount.
 3. Bubbler and Valve: Chrome plated brass, automatic stream control, push button valve with bubbler designed to provide uniform stream without spurting. Push button shall not be plastic.
 4. Waste: Concealed 1-1/4inch O.D. tailpiece, chrome plated waste strainer and 1-1/4inch I.P.S. trap.
 5. Supply: 1/2inch I.P.S. screwdriver stop with water strainer assembly.
 6. Grille: Stainless steel, one-piece louvered grille matching receptor.
 7. Refrigeration System: Refrigerant R-134A, hermetically sealed, capillary tube. All joints lead free silver soldered.
 - a. Compressor: Hermetically sealed, with automatic reset overload protection.
 - b. Condenser: Air-cooled
 - c. Cooling Unit: Tube type, self-cleaning, continuous coil of seamless copper.
 - d. Temperature Control: Thermostat with adjustable range of 45 degrees F. to 55 degrees F., factory set at 50 degrees F.
 8. Electrical Characteristics: 120 volts, 60 Hz, 4.5 amperes, 1/5 HP, provide 3-prong power lead-in cord.

9. Capacity: 8.0 GPH of 50 degrees F. water, with ambient temperature of 90 degrees F., and 80 degrees F. entering water temperature.
10. Mounting: Frame manufactured of heavy gauge galvanized steel with pre-drilled mounting holes.
 - a. Haws Model No. HWCF8

C. EWC-[] Wall Mounted Electric Water Coolers - Barrier Free - High/Low

1. Units shall be factory assembled and tested, listed and labeled in compliance with UL Standard 399, and have capacities rated in accordance with ASHRAE Standard 18, and ARI Standard 1010.
2. Cabinets: Surface mounted, heavy gauge, welded steel cabinet, with removable front panel and hanger bracket for wall mounting. Cabinet finish and color as selected by the Architect. (Standard color is a brush sterling.)
3. Tops: Deep basin, anti-splash, smoothly contoured stainless steel with raised bubbler mount, chrome plated brass strainer, and 1-1/4inch tailpiece.
4. Bubblers and Valves: Chrome plated brass, automatic stream control, push-button valve with bubbler designed to provide uniform stream without spurting. Push bars shall not be plastic.
5. Refrigeration System: Refrigerant R-134A, hermetically sealed, capillary tube. All joints lead free silver soldered.
 - a. Compressor: Hermetically sealed, with automatic reset overload protection.
 - b. Condenser: Air-cooled
 - c. Cooling Unit: Tube type, self-cleaning, continuous coil of seamless copper.
 - d. Temperature Control: Thermostat with adjustable range of 45 degrees F. to 55 degrees F., factory set at 50 degrees F.
6. Electrical Characteristics: 120 volts, 60 Hz, 1/6 HP, 3.0 amperes, provide 3-prong power lead-in cord.
7. Capacity: 8.0 GPH of 50 degrees F. water, with ambient temperature of 90 degrees F., and 80 degrees F. entering water temperature.
8. Connections: Provide Trap, and supply and stop as specified in the Articles below.
9. Provide 4inch air space on both sides of unit for cooling air flow.
10. Provide tubular steel supports bolted to floor.
 - a. Haws Model No. HWBFA8L.

D. EWC-[] Wall Mounted Barrier Free Water Cooler, High/Low:

1. Units shall be factory assembled and tested, listed and labeled in compliance with UL Standard 399, and have capacities rated in accordance with ASHRAE Standard 18, and ARI Standard 1010.

2. Receptors: Heavy gauge, stainless steel, with No. 4 finish on the outside, raised bubbler mount.
3. Bubblers and Valves: Chrome plated brass, automatic stream control, push button valve with bubble designed to provide uniform stream without spurting. Push button shall not be plastic.
4. Waste: Concealed (2) 1-1/4inch O.D. tailpieces, (2) chrome plated waste strainers and (2) 1-1/4inch I.P.S. traps.
5. Supply: 1/2inch I.P.S. screwdriver stop with water strainer assembly.
6. Grille: Stainless steel, one-piece louvered grille matching receptor.
7. Refrigeration System: Refrigerant R-134A, hermetically sealed, capillary tube. All joints lead free silver soldered.
 - a. Compressor: Hermetically sealed, with automatic reset overload protection.
 - b. Condenser: Air-cooled
 - c. Cooling Unit: Tube type, self-cleaning, continuous coil of seamless copper.
 - d. Temperature Control: Thermostat with adjustable range of 45 degrees F. to 55 degrees F., factory set at 50 degrees F.
8. Electrical Characteristics: 120 volts, 60 Hz, 4.5 amperes, 1/5 HP, provide 3-prong power lead-in cord.
9. Capacity: 8.0 GPH of 50 degrees F. water, with ambient temperature of 90 degrees F., and 80 degrees F. entering water temperature.
 - a. Haws Model No. HWCF8-2
10. Mounting: Frame manufactured of heavy gauge galvanized steel with pre-drilled mounting holes.

2.4 FAUCETS:

A. Sink Trim

1. Single Compartment Sink Fitting, Low Profile Swing Spout

All brass concealed type supply faucet with renewable seats, one piece/three piece top cover escutcheon, 8inch low profile swing spout with aerator/3/4 gpm aerator/2.5 gpm aerator outlet vandal proof/lever/cross/4inch wrist blade handles, 1/2inch male thread inlet with coupling nuts, chrome plated exterior finish.

Chicago Faucet No.201A/1201A/1100 or equivalent by approved manufacturer.

3-1/2inch diameter 316 stainless steel basket type strainer with rubber seat stopper and 1-1/2inch tailpiece.

2. Double Compartment Sink Fitting, Low Profile Swing Spout with Optional Spray and Food Waste Disposer.

All brass concealed type supply faucet with renewable seats, one piece/three piece cover escutcheon, 8inch low profile swing spout with aerator /3/4 gpm aerator/2.5 gpm aerator outlet vandal proof/lever/cross/4inch wrist blade handles, 1/2inch male thread inlets 8inch on center with coupling nuts, chrome plated exterior finish. Provide diverter valve in faucet with hose, spray head and deck escutcheon.

Chicago Faucet No. 200A/1200A/1102 with lever/cross/4inch wrist blade handles or equivalent by approved manufacturer.

1 or 2 3-1/2inch diameter 316 stainless steel basket type strainers with rubber seat stopper and 1-1/2inch tailpiece.

1-1/2inch 17 gauge tubular brass end/center outlet continuous waste with cast brass tee flow directing, 1-1/2inch tailpiece/1-1/2inch tailpiece with 3/4inch chrome plated.

3. Single Compartment Sink Fitting, Gooseneck Spout, Wrist Blade Handles

All brass concealed type supply faucet with renewable seats, three piece cover escutcheons, 5-3/8inch x 9-3/4inch high gooseneck swing spout with aerator/3/4 gpm aerator/vacuum breaker and aspirator/flow control-laminar flow outlet vandal proof, 4inch wrist blade handles, 1/2inch male thread inlets on 8inch on center with coupling nuts, chrome plated and exterior finish.

Chicago Faucet No. 785 or equivalent by approved manufacturer.

3-1/2inch diameter drain fitting /flat grid stainless steel/basket type stainless steel/316 stainless, flat grid with 1-1/2inch /stainless steel/316 stainless tailpiece.

4. Double Compartment Sink Fitting, Gooseneck Spout, Wrist Blade Handles

All brass concealed type supply faucet with renewable seats, three piece cover escutcheons, 8inch x 11-1/4inch high swing spout with aerator/3/4 gpm aerator/vacuum breaker and aspirator/flow control - laminar flow outlet vandal proof, 4inch wrist blade handles, 1/2inch male thread inlets 8inch on center with coupling nuts, chrome plated exterior finish.

Chicago Faucet No. 785 or equivalent by approved manufacturer.

3-1/2inch diameter drain fitting flat grid stainless steel/basket type stainless steel/316 stainless, flat grid with 1-1/2inch stainless steel/316 stainless tailpiece.

5. Utility Sink Wall Mounted

Back mounted, all brass supply faucet with lever handles, 8inch swing spout with aerator outlet, soap dish, integral stop arms with flanges, 1/2inch female thread inlets; chrome plated.

Kohler No. K-7855 or equivalent by approved manufacturer.

3-1/2inch diameter drain fitting flat grid stainless steel/ basket type stainless steel/316 stainless, flat grid with 1-1/2inch stainless steel/316 stainless tailpiece.

6. Mop Service Basin

Wall mounted, all brass supply faucet, 10inch spout with wall brace, 3/4inch male hose thread outlet and vacuum breaker, lever handles, loose key stops in shanks, wall flanges and 1/2inch female thread inlets, chrome plated finish.

Chicago Faucet No. 897 or equivalent by approved manufacturer.

B. Lavatory Trim

Edit Note: If trim is for ADA fixture, change tailpiece to "offset type tailpiece."

1. Center Set Faucet, Open Grid Drain

All brass, one piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 4inch on center with coupling nuts, 3-3/4inch spout with 1/2 gpm aerator outlet, vandal proof, lever/4inch wrist blade handles. Chrome plated exterior finish.

Open grid drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No. 5500-170VP (wrist blades)/5500.140VP (lever handles) or equivalent by approved manufacturer.

2. Wide Spread Faucet, Open Grid Drain

All brass, 3-piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 8inch on centers with coupling nuts and rigid connectors, 4inch spout, 1/2 GPM aerator outlet, vandal proof, lever, 4inch wrist blade; Handles chrome plated exterior finish.

Open grid drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No. 6500.170VP (wrist bladed)/6500.140VP (lever handles) or equivalent by approved manufacturer.

3. Center Set Faucet, Pop-Up Drain

All brass, one piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 4inch on center with coupling nuts, 3-3/4inch spout with 1/2inch gpm aerator outlet, vandal proof, lever/4inch wrist blade handles, hole in faucet body for waste actuator rod, waste actuator rod with chrome knob, chrome plated exterior finish.

Pop-up drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No. 5501.170 (wrist blades)/5501.140 (lever handles) or equivalent by approved manufacturer.

4. Wide Spread Faucet, Pop-Up Drain

All brass, 3-piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 8inch on center with coupling nuts and rigid connectors, 4inch spout with 1/2 gpm aerator outlet, vandal proof, chrome plated brass 4inch wrist blade/lever handles, hole in spout for waste actuator rod, waste actuator rod with chrome knob, chrome plated exterior finish.

Pop-up type drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No.6501.170 (wrist blades)/6501.140 (lever handles) or equivalent by approved manufacturer.

5. Center Set Faucet, Gooseneck Spout, wrist blade handles, open grid drain

All brass, one piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 4inch on center with coupling nuts, rigid/swing gooseneck spout 5inch x 10-5/8inch high with 1/2 gpm aerator outlet vandal proof, 4inch wrist blade handles, chrome plated exterior finish.

Open grid drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No. 7500.170VP or equivalent by approved manufacturer.

6. Wide Spread Faucet, Gooseneck Spout, Wrist Blades, Open Grid Drain.

All brass, three piece supply faucet with ceramic disk valving, 1/2inch male thread inlets 8inch on center with coupling nuts and rigid connectors, 5inch x 10-5/8inch high gooseneck spout with 1/2 gpm aerator outlet, vandal proof, 4inch wrist blade handles, chrome plated exterior finish.

Open grid drain assembly, chrome plated brass with 1-1/4inch tailpiece.

American Standard No. 6530.170VP or equivalent by approved manufacturer.

7. Wheelchair Lav, Wide Spread Faucet, Gooseneck Spout, Wrist Blades, Open Grid Drain

All brass, three piece supply faucet with ceramic disk valving, 1/2inch male thread inlets, 12inch on center with coupling nuts and flexible connectors, 5inches x 10-5/8inches high gooseneck spout 6inches above slab with 1/2 gpm aerator outlet, vandal proof, 4inch wrist blade handles, chrome plated exterior finish.

Open grid drain assembly with 1-1/4inch off-set type tailpiece for wheel chair, chrome plated brass.

American Standard No. 6930.170VP equivalent by approved manufacturer.

2.5 FLUSH VALVES:

A. Water Closet

Exposed type, quiet action, flush valve, all brass, chrome plated, oscillating non hold open handle, 1inch screwdriver angle stop with vandal resistant cap, vacuum breaker, 1-1/2inch flushing connection with tailpiece, spud coupling for 1-1/2inch top spud, wall and spud flanges, sweat solder adaptor, low consumption 1.6 GPF, handle shall conform to A.D.A. requirements.

Sloan Royal 111 or equivalent by approved manufacturer.

B. Urinal, Siphon Jet or Washout

Exposed type, quiet action, flush valve, all brass, chrome plated, oscillating non hold open handle, 3/4inch screwdriver angle stop with vandal resistant cap, vacuum breaker, 3/4inch flushing connection with tailpiece, spud coupling for 3/4inch top spud, wall and spud flange, sweat solder adaptor, low consumption 1.0 GPF, handle shall conform to A.D.A. requirements.

Sloan Royal 186-1 or equivalent by approved manufacturer.

C. Urinal Blowout

Exposed type, quiet action, flush valve, all brass, chrome plated, oscillating non hold open handle, 1inch screwdriver angle stop with vandal resistant cap, vacuum breaker, 1-1/4inch flushing connection with tailpiece, spud coupling for 1-1/4inch top spud, wall and spud flanges, sweat solder adapter, low consumption, 1.0 GPF.

Sloan Royal 180-1 or equivalent by approved manufacturer.

2.6 SINK BUBBLER:

- A. All brass, push button, self closing angle stop bubbler angle stream nozzle with drain lip. Volume control in shank, 1/2inch male shank inlet with coupling nut, replaceable cartridge, chrome plated exterior finish, counter top mounting.

Just Model No. JCB-2

Just Model No. JSB-10/ADA/Vandal Resistant

- B. All brass, pushbutton, self closing angle stop bubbler, angle stream nozzle with drain lip, volume control in shank, 1/2inch male thread inlet with coupling nut, chrome plated exterior finish, counter top mounting.

Chicago Faucet No. 748-665

2.7 FIXTURE SUPPORTS:

- A. Lavatory Supports: Commercial grade adjustable cast iron, with thin concealed arms and sleeves, and complete with escutcheons and mounting fasteners.
- B. Lavatory Supports: Commercial grade cast iron supports, having tubular steel uprights with concealed arms and sleeves, mounted on adjustable headers and complete with heavy cast iron short feet bolted to floor, alignment trusses, and mounting fasteners.
- C. Water Closet: Commercial grade adjustable, factory painted, cast iron face plate, support base, and appropriate type waste fitting having face plate gasket; zinc plated steel fixture studs and fasteners; coated and threaded adjustable wall coupling with neoprene closet outlet gasket; and chrome plated fixture cap nuts and fiber fixture washers. Provide an appropriate model to suit deep or shallow rough-in, siphon jet or blow-out action and type of sanitary piping system to which it is connected.
- D. Wheelchair Water Closet Supports: Commercial grade adjustable, factory painted, cast iron face plate, support base, and appropriate type waste fitting having face plate gasket; zinc plated steel fixture studs and fasteners; coated and threaded adjustable wall coupling with neoprene closet outlet gasket; and chrome plated fixture cap nuts and fiber fixture washers. Units shall have elevated mounting heights of wheelchair fixtures, siphon jet or blow-out action water closet, and type of sanitary piping system to which it is connected.
- E. Urinal Supports: Commercial grade supports for urinals shall have steel top and bottom plates with bolts to support fixture independently from the wall; adjustable sleeves, steel tubular uprights bolted to floor and alignment trusses, steel plates with adjustable holes, bolts, nuts, and chrome plated cap nuts and washers. Top supporting plates shall have cutouts when used with back inlet urinals.

2.8 TOILET SEATS:

A. Toilet Seats

Elongated open front, less cover. Solid plastic, high impact, commercial weight stainless steel hinge posts self-sustaining check hinge. Color shall match fixture.

Church No. 9500SSC

2.9 FITTINGS, TRIM, AND ACCESSORIES:

- A. Supplies and Stops for Lavatories and Sinks: polished chrome-plated, loose-keyed/wheel handle angle stop having 1/2inch inlet and 3/8inch O.D. x 12inch long flexible tubing outlet, and wall flange and escutcheon. Quantity to match trim specified.
- B. Supplies and Stops for Water Closets: polished chrome-plated, loose-keyed/wheel handle angle stop having 1/2 inch inlet and 3/8 inch O.D. x 12inch long flexible tubing outlet with collar, and wall flange and escutcheon.
- C. Traps for Drinking Fountains and Lavatories: 17 gauge tubular brass, 1-1/4inch adjustable "P" trap and waste to wall.
- D. Traps for Sinks: cast brass, 1-1/2inch adjustable "P" trap and waste to wall.
- E. Escutcheons: chrome-plated cast brass with set screw.
- F. All ADA Accessible lavatories, supplies and waste shall be insulated with molded vinyl covers. Truebro Inc. Lav-Guard insulation Kit, or approved equivalent.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Verify all dimensions by field measurements. Verify that all plumbing fixtures may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- B. Examine rough-in for potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.
- C. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturer's written instructions, rough-in drawings, and pertinent codes and regulations, the original design, and the referenced standards.
- B. Fasten plumbing fixtures securely to supports or building structure. Secure supplies behind or within wall construction to provide rigid installation.
- C. Set mop basins in a leveling bed of cement grout.
- D. Install a stop valve in an accessible location in the water connection to each fixture.

- E. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork.
 - F. Seal fixtures to walls and floors using silicone sealant as specified in Section 07900. Match sealant color to fixture color.
 - G. Visible parts of fixture brass and accessories shall be chrome plated.
 - H. External finishes on all trim shall not be chrome plated plastic.
 - I. Where possible, fixtures shall be product of one manufacturer. Where possible, fittings of same type shall be product of one manufacturer.
 - J. Install hose end faucets and hose connection with vacuum breakers.
 - K. Solidly attach floor mounted water closets to floor with hex expansion shield of cast iron closet flanges.
- 3.3 ADA ACCESSIBILITY:
- A. Review Mechanical and Architectural drawings to determine fixtures requiring ADA accessibility. Notify Architect/Engineer of any physical conflicts preventing full dimensional compliance prior to beginning work.
 - B. Comply with the installation requirements of ANSI A117.1 and Public Law 90-480 with respect to plumbing fixtures for the physically handicapped. Arrange flush valve/flush tank handles with proper orientation to meet ADA requirements.
- 3.4 FIELD QUALITY CONTROL:
- A. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, then retest.
 - B. Inspect each installed unit for damage. Replace damaged fixtures.
- 3.5 ADJUSTING:
- A. Adjust water pressure at drinking fountains, faucets, shower valves, and flush valves to provide proper flow and stream.
 - B. Replace washers of leaking or dripping faucets and stops.
 - C. Clean fixtures, trim, and strainers using manufacturer's recommended cleaning methods and materials.
- 3.6 CLEANING:
- A. Clean fixtures, trim, and strainers using manufacturer's recommended cleaning methods and materials.
- 3.7 PROTECTION:
- A. Provide protective covering for installed fixtures, water coolers, and trim.

- B. Do not allow use of fixtures for temporary facilities unless expressly approved in writing by the Owner.

3.8 MOUNTING HEIGHTS SCHEDULE:

Edit Note: Verify that Architect is providing a mounting height schedule.

- A. Fixture mounting height and rough-in dimensions shall be as indicated on the architectural drawings and specifications.

3.9 WATER CONSERVATION:

All plumbing fixtures shall be of water conservative design. Provide as a minimum devices to restrict water flow as follows:

- | | | |
|----|----------------------------|------------------------------|
| 1. | Lavatory | 1/2 gpm |
| 2. | Sink | 2.5 gpm |
| 3. | Mop Sink | 1.6 gpm hot and 1.6 gpm cold |
| 4. | Water Closets (siphon jet) | 1.6 gallons per flush |
| 5. | Urinals (siphon jet) | 1 gallon per flush |

Flow control devices shall maintain flow rate shown regardless of inlet pressure.

END OF SECTION 15440

SECTION 15456 - WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of water treatment system work required by this section is indicated on drawings and schedules and by requirements of this section, and includes necessary equipment, chemicals, and service for the following systems:
 - 1. Closed Hot Water Systems
 - 2. Closed Chilled Water Systems
 - 3. Cleaning of Piping Systems
 - 4. Sterilization of Domestic Water System

- B. Provide chemicals and service program for a period of one year from start-up date of equipment, including the following:
 - 1. Initial water analysis and recommendations.
 - 2. Systems start-up assistance.
 - 3. Training of operating personnel.
 - 4. Periodic field service and consultation.
 - 5. Customer report charts and log sheets.
 - 6. Laboratory technical assistance.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's and Representative Qualifications. Firms regularly engaged in manufacture of water treatment equipment, chemical and service shall have been active in the field of industrial water treatment and whose products have been in satisfactory use in similar service for not less than 5 years, and shall have full-time service personnel located within the trading area of job site.

- B. Codes and Standards:
 - 1. ASME Compliance: Construct softener tanks in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, provide stamp and certification.
 - 2. UL Labels: Provide water conditioners ancillary electrical components, which have been listed and labeled by UL.
 - 3. NEMA Standards: Provide electrical controls and enclosures conforming to applicable standards of NEMA for environment where water conditioners are indicated.
 - 4. NSE Compliance: Construct and install water conditioners in accordance with NSF Standard 44 "Cation Exchange Water Softeners Relating to Supplementary Treatment of Potable Water."
 - 5. Chemical Standards: Provide only chemical products, which are acceptable under state and local public health and pollution control regulations.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product including rated capacities of selected equipment clearly indicating water pressure drops, weights, installation and start-up instructions, and furnished specialties and accessories.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to water treatment equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 1 and 15.
- E. Maintenance Data: Submit maintenance data and parts list for each item of equipment, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of Division 15.

1.4 DELIVERY, STORAGE AND HANDLING:

- A. Handle water treatment materials and components carefully to prevent damage, breaking, denting and scoring to materials and equipment. Deliver packaged units in original crates. Do not install damaged water treatment materials and components; remove from site and replace with new.
- B. Store water treatment materials and components in an environment satisfactory to prevent their damage by the elements.

1.5 EXTENDED MAINTENANCE SERVICES:

- A. Agreement to Maintain: Prior to time of final acceptance, submit four copies of "Agreement for continued Service and Maintenance" for water treatment system, for Owner's possible acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing, and including replacement of materials and equipment, for one-year period with option for renewal of Agreement by Owner.

PART 2 - PRODUCTS

2.1 SUPPLIERS:

- A. Suppliers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Water Treatment System:
 - a. Summitt Labs
 - b. Mogul Div.
 - c. International Chemtex

2.2 CLOSED SYSTEMS:

- A. Provide a closed system chemical feed and control system sized and equipped to treat the raw makeup water available at the project site.
- B. Except as otherwise indicated, provide closed water treatment system of manufacturer's standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.
- C. BY-PASS FEEDER:
 - 1. Provide a By-Pass Feeder for adding chemical to the closed water system. The Feeder shall have two 3/4inch NPT female pipe connections, and a 3-1/2inch quick top opening cap, with "O" ring seat. Capacity of the Feeder shall be [] gallons, capable of operating at 250 psig and at a temperature up to 212 degrees F. The by-Pass feeder shall be mounted no higher from the floor than 48 inches.
- D. GLYCOL FEEDER:
 - 1. Provide Glycol Feed System consisting of a 50 gallon polyethylene tank with a removable polyethylene tank cover. A 1/2inch suction and underdrain system, with hose bib, for draining the tank, and a pump shut off valve. The tank shall be supported by four steel legs with foot pads and the pump mounted under, for positive suction, as an integral part of the tank.
 - 2. The control cabinet shall be a NEMA 1 enclosure with Lexan viewing window mounted in the cabinet door. The following components shall be mounted on the inside panel: Low liquid level alarm light, low liquid level alarm silencer switch, pump test switch and, pump operating, indicating light. A 0 - 60 psi system pressure gauge. An adjustable drum low level sensor shall prevent the positive displacement pump from operating when the tank liquid level is low and shall also audibly sound an alarm when tank level is low. In addition, two extra normally open dry contacts shall be provided for remote low tank level warning alarm. A 3 - 35 psi adjustable pressure switch shall control the system pressure.
 - 3. The pump shall be an Oberdorfer or approved equivalent, all bronze, rotary gear pump with a 1/2 HP 1725 rpm motor mounted integrally with the pump. The pump shall be designed to produce 1.8 gpm at 40 psig. Electrical characteristic: 120 v/60 HZ/1phase/1/3 HP.
 - 4. The glycol Feeder discharge shall consist of a 3/4inch check valve, 3/4inch threaded female "T", for connecting the Glycol Feeder to the system piping, and a Watts pressure relief valve set at 50 psig, which will dump any closed system over pressure, back into the Glycol Mixing Tank.
- E. GLYCOL TRANSFER PUMP:
 - 1. Provide a Hand-Operated Rotary Transfer Pump with 8 feet of 1 inch hose and a non-sparking 3/4inch nozzle for the transferring of glycol from the glycol container to the glycol feed tank. The pump shall have a 1 inch telescoping suction pipe, and bung adapter with 2 inch thread.

PART 3 - EXECUTION

3.1 CLEANING OF PIPE LINES AND BOILERS:

- A. The water treatment contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the chilled and/or heating piping.
- B. The system to be cleaned shall be filled with a solution of 10% by weight of a heavy duty alkaline liquid cleaner. The cleaner shall be capable for wetting and penetrating heavy soil deposits of oil or grease, and keeping these products in suspension, for removal through a Filter Feeder.
- C. The cleaning solution shall be circulated for a minimum of 8 hours, with the Filter Feeder being back-washed as required to remove solids which have been cleaned from the system.
- D. At the end of the cleaning period, the alkalinity in the system shall be reduced to the pH of the incoming raw water. The system shall then be chemically treated as specified. In no case shall the system being cleaned be left in an untreated condition for more than 8 hours.
- E. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the system was cleaned as specified.

OR

- F. The Water Treatment Contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the chilled and/or heating piping.
- G. The system to be cleaned shall be filled with a solution of 10 percent by weight of a heavy duty alkaline liquid cleaner. The cleaner shall be capable of wetting and penetrating heavy soil deposits of oil or grease, and keeping these products in suspension, for removal through flushing the system to drain.
- H. The cleaning solution shall be circulated for a minimum of 8 hours. At the end of the eight hours, the system shall be flushed to drain, and then refilled with fresh water, taking care to remove any entrapped air from the system.
- I. At the end of the cleaning period, the system shall be chemically treated as specified. In no case shall the system being cleaned be left in an untreated condition for more than 8 hours.
- J. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the system was cleaned as specified.

3.2 CHLORINATION:

- A. Acceptable products are:

Liquid Chlorine	<u>[Fed. Spec. BB-C120B]</u>
Hypochlorite	<u>[Fed. Spec 0-C-114, Type 11, Grade B]</u>
	<u>[Fed. Spec. 0-S-60D, Grade A or B]</u>

- B. After all pressure tests have been performed and piping has been flushed clean, the chemical treatment contractor shall be responsible for sterilizing the domestic water lines and fire protection lines.

- C. Chlorination procedures shall comply with local code and health department regulations.
1. The Mechanical Contractor shall inform the General Contractor that the water system is to be chlorinated 48 hours in advance, so that arrangements can be made for other trades not to use the water.
 2. Before commencing the chlorination process, the Water Treatment Contractor shall post signs at each water fountain, and on each restroom door, stating that the water is not fit for drinking, and that the water is being chlorinated.
 3. Introduce sufficient chlorine into the domestic water system to provide a dosage of not less than 50 parts per million at each faucet and valve. The chlorine solution shall then be allowed to stand for a minimum of 24 hours in the system.
 4. At the end of 24 hours test shall be made for residual chlorine at the extreme end of the system from the point where chlorine was introduced. If chlorine residual is less than 10 ppm, the chlorination procedure shall be repeated.
 5. Flush the system with a clean supply of water until the chlorine residual in the system is reduced to less than 1 ppm, or to the chlorine residual of the supply water. During the flushing, each faucet and valve in the system shall be opened and closed a minimum of 4 times.
 6. After 24 hours, the water treatment representative will have samples taken and tested by an independent laboratory. The system must be free of bacteriological contamination. If the system is contaminated, it shall be re-chlorinated until a satisfactory test is made.
 7. The Water Treatment Contractor shall write a letter, informing the Mechanical Contractor that the building has been successfully chlorinated, and that the water is fit for human consumption.

3.3 TESTING

A. Closed Systems:

1. Provide a Nitrite "Drop Test" kit for determining the level of Nitrite or Molybdate in the closed system.

3.4 COUPON RACKS:

A. Coupon Rack for Closed Systems:

1. Install as shown on the drawings two coupon holders between the low and high pressure of the circulating pump. The coupon holders shall be isolated with shut off valves for removing and inspecting the coupons.

When the system is ready for startup, the Water Treatment Contractor shall install two pre-weighted coupons, one copper, and the other steel in the above coupon holders, noting time and date. At the end of 90 days, the coupons shall be removed, noting the time and date, re-weighted, and inspected, with a report being sent to the mechanical contractor, for distribution to the proper people, showing the condition of the system being treated.

3.5 INSTALLATION:

- A. Coordination where installation of Water Treatment equipment in piping systems is required with the other work (plumbing and heating piping) as necessary to interface components of water treatment equipment. Provide installation instructions to those firms providing installation.
- B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
 - 2. Install pressure gauges, valves, and controls furnished by manufacturer, in accordance with manufacturer's instructions.

3.6 INSPECTION:

- A. Examine areas and conditions under which water treatment systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.7 FIELD QUALITY CONTROL:

- A. Sample water softener effluent at one-week intervals after start-up for period of 3 weeks and prepare test report on the conditions of the water.

3.8 SYSTEM START-UP:

- A. The Water Treatment Supplier shall put the system into operation, and make adjustments necessary for proper operation.
- B. The Water Treatment Supplier shall provide a written report to the Division 15 Contractor indicating that the start-up has been completed and that all Water Treatment Equipment is operating properly.

3.9 TESTING AND CLEANING:

- A. Sample all treated water systems at one-week intervals after start-up for period of 4 weeks and prepare certified test report for each system being treated.
- B. Start-up test, and adjust water conditioners in presence of manufacturer's authorized representative. Operate units including regeneration, back washing, rinsing and flushing. Adjust unit to maintain required steady state effluent water quality.
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.10 EXTRA STOCK:

- A. In addition to startup salt, furnish ten 80-lb bags of salt on a pallet and store where requested by Owner. Obtain a receipt from Owner for this salt.

3.11 CLOSEOUT PROCEDURES:

- A. Provide services of manufacturer's technical representative for one 8 hour day to instruct Owner's personnel in operation and maintenance of water treatment systems.
 - 1. Schedule training with Owner, provide at least 7 day notice to Contractor and Engineer of training date.

END OF SECTION 15456

SECTION 15458 - WATER HEATERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of water heater work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Refer to other Division 15 sections for piping, specialties, pumps, fuel piping; breechings which are required external to water heaters for installation; for field installed automatic temperature controls required in conjunction with water heaters; not work of this section.
- C. Electrical Work: Refer to Division 15 section "Mechanical/Electrical Requirements for Mechanical Equipment" for requirements.
- D. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 16:
 - 1. Low voltage wiring between water heaters and remote mounted thermostats and controls.
 - 2. Provide factory-mounted and factory-wired controls and electrical devices as specified in this section.
- E. Refer to Division 16 sections for other electrical wiring including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of water heaters of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. UL Compliances: Construct water heaters in accordance with the following UL standards:
 - a. UL 174, "Household Electric Storage-Tank Water Heaters".
 - b. UL 1453, "Electric Booster and Commercial Storage Tank Water Heaters".
 - 2. Provide water heater components which are UL-listed and labeled.
 - 3. NSF Compliance: Construct and install water heaters located in food service establishments in accordance with NSF 5, "Standard for Hot Water Generating Equipment for Food Service Establishments using Spray Type Dish washing Machines".
 - 4. NEC Compliance: Install electric water heaters in accordance with requirements of NFPA 70, "National Electrical Code".
 - 5. NFPA Compliance: Install gas-fired water heaters in accordance with requirements of NFPA 54, "National Fuel Gas Code".

6. NFPA Compliance: Install oil-fired water heaters in accordance with requirements of NFPA 31, "Installation of Oil Burning Equipment".
7. AGA and NSF Labels: Provide water heaters which are listed and labeled by American Gas Association and National Sanitation Foundation.
8. ASME Code Symbol Stamps: Provide water heaters and safety relief valves which comply with ASME Boiler and Pressure Vessel Code, and are stamped with appropriate code symbols.
9. ASHRAE Compliance: Provide water heaters with Performance Efficiencies not less than prescribed in ASHRAE 90A, "Energy Conservation in New Building Design".

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data including rated capacities and efficiencies of selected model clearly indicated; operating weights; furnished specialties and accessories; and installation and start-up instructions.
- B. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for electrical power supply wiring to water heaters. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls. Differentiate between portions of wiring that are factory-installed and portions that are to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 15.
- E. Maintenance Data: Submit maintenance data and parts lists for each type and size of water heater, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 15.
- F. Certificates: Submit appropriate Certificates of Shop Inspection and Data Report as required by provisions of ASME Boiler and Pressure Vessel Code.

1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Handle water heaters and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged water heaters or components; remove from site and replace with new.
- B. Store water heaters and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with manufacturer's rigging and installation instructions for unloading water heaters, and moving units to final location for installation.

1.5 SPECIAL PROJECT WARRANTY:

- A. Warranty on Coil, Heat Exchanger, and Burner: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, coils, heat exchangers, and burners with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's

instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Commercial Gas-Fired:
 - a. Bock Water Heaters, Inc.
 - b. Lockinvar Water Heater Corp.
 - c. PVI Industries, Inc.
 - d. Rheem Water Heater Div; City Investing Co.
 - e. Ruud Water Heater Div; City Investing Co.
 - f. Smith Corp. (A.O.); Consumer Products Div.
 - g. State Industries, Inc.
 - h. Viking Superior Corp.

2.2 COMMERCIAL GAS-FIRED WATER HEATERS:

- A. General: Provide commercial gas-fired water heaters of sizes and capacities as indicated on schedule. Provide certification of design by AGA under Volume III tests for commercial water heaters for delivery of 180 degrees F (82 degrees C) water.
- B. Heater: Construct for working pressure of 150 PSI; boiler type hand hole cleanout; magnesium anode rod; 3/4inch tapping for relief valve; glass lining on internal surfaces exposed to water.
- C. Safety Controls: Equip with automatic gas shutoff device to shut off entire gas supply in event of excessive temperature in tank; and pilot safety shutoff.
- D. Draft Hood: Equip with AGA certified draft hood.
- E. Jacket: Insulate tank with vermin-proof glass fiber insulation. Provide outer steel jacket with baked enamel finish over bonderized undercoating.
- F. Accessories: Provide brass drain valve; 3/4inch pressure and temperature relief valve; and radiant floor shield.
- G. Controls: Provide gas pressure regulator; pilot gas regulator; thermostat; and temperature limit control.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas and conditions under which water heaters are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF WATER HEATERS:

- A. General: Install water heaters in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
- B. Support: Place units on concrete pads, orient so controls and devices needing service and maintenance have adequate access.
- C. Piping: Connect hot and cold water piping to units with shutoff valves and unions. Connect recirculating water line to unit with shutoff valve, check valve, and union. Extend relief valve discharge to closest floor drain, or as indicated.
- D. Gauges: Provide thermometers on inlet and outlet piping of water heaters, in accordance with Basic Mechanical Materials and Methods Section "Meters and Gauges."
- E. Gas-Fired Water Heaters: Connect gas supply to gas line with drip leg, tee, gas cock, and union; full size of unit inlet connection. Locate piping so as not to interfere with service of unit.
 - 1. Flue: Connect flue to draft hood with gas-tight connection. Provide flue of minimum size as flue outlet on heater. Comply with gas utility requirements.

3.3 FIELD QUALITY CONTROL:

- A. Start-Up: Start-up, test, and adjust gas-fired water heaters in accordance with manufacturer's start-up instructions, and utility company's requirements. Check and calibrate controls, adjust burner for maximum efficiency.

3.4 CLOSEOUT PROCEDURES:

- A. Training: Provide services of manufacturer's technical representative for 1-half day to instruct Owner's personnel in operation and maintenance of water heaters.
 - 1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 15458

SECTION 15517 - GLYCOL SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of glycol system required by this section is indicated on drawings and/or specified in other Division 15 sections.
- B. Types of glycol system specialties specified in this section include the following:
 - 1. Fill tank
 - 2. Pressure sensor
 - 3. Pressure relief valve
 - 4. Check valve
 - 5. Propylene glycol
 - 6. Feed Pump
 - 7. Transfer Pump
- C. Glycol systems specialties furnished as part of factory-fabricated equipment shall meet or exceed requirements of this section.
- D. Refer to other Division 15 sections for mechanical insulation valves, meters and gauges and basic piping materials and methods.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of glycol systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Glycol System Types: Provide glycol system specialties of same type by same manufacturer.
- C. Codes and Standards: Provide glycol system components and materials to meet all local and national codes and standards.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including installation instructions and dimensioned drawings for each type of manufactured equipment and material. Include pressure drop information. Submit schedule showing manufacturer's model or figure number, size, location and features for all equipment and material.
- B. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured equipment. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.
- C. Submit glycol solution strength test results.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. Glycol System Tank:
 - a. Wetcorp
 - b. Sage Industries
 - c. Nalco
 - d. Mogul
 - e. Chem Aqua
 - f. H.O.H.
2. Inhibited Propylene Glycol Solution:
 - a. Dow Chemical Dowfrost
 - b. Interstate Chemical Intercool NFP.

2.2 REFER TO DIVISION 15, SECTION 15055 FOR TYPE OF PIPE AND FITTINGS TO BE USED.

2.3 GLYCOL SYSTEM:

- A. Tank: Provide Glycol Feed System consisting of a 35 [] gallon polyethylene tank with a removable polyethylene cover. A ½ inch suction and under drain with hose bib for draining the tank and a pump shut off valve shall be provided. The tank shall be supported by 4 legs with foot pads as an integral part of the tank.
- B. Controls: The control cabinet shall be a NEMA I enclosure with a large LEXAN viewing window mounted in the cabinet door. The following components shall be mounted on the inside panel: Low level liquid alarm light, low level alarm silencer switch, pump test switch and indicating light, and a 0-60 psi system pressure gauge. The low level switch shall be mounted 3inches above the bottom of the tank. A low level audible alarm shall be mounted in the side of the panel. In addition, two extra, normally open contacts shall be provided for remote low level warning light or alarm. A 3-35 psi adjustable pressure switch shall control the system pressure.
- C. Pump: The pump shall be an Oberdorfer, all bronze, rotary gear pump with a 1/3 hp-1725 rpm motor mounted integrally with the pump. The pump shall be designed to produce 1.8 gpm at 40 psi. Electrical characteristics: 120V./60Hz/1 phase/1/3 HP.
- D. Piping: Type L copper pump discharge, including a 3/4inch check valve, 3/4inch threaded female "T" for connecting the Glycol Feeder to the system piping, and a Watts pressure relief valve set at 50 psi, which will dump any system over pressure back to the glycol feed tank.
- E. Transfer Pump: Hand operated rotary type, 8feet-0inches long 1inch hose with 3/4inch non-sparkling nozzle, 1inch telescoping suction pipe, adaptor with 2inch thread.

2.4 GLYCOL SOLUTION:

- A. Provide 30percent glycol solution for burst protection to a temperature of [].
- B. Provide on extra 45 gallon drum of propylene glycol.

PART 3 EXECUTION

3.1 INSTALLATION:

- A. Refer to drawing and provide necessary piping to complete installation.

- B. Thoroughly clean and flush system before adding propylene glycol solution.
- C. Feed pre-mixed propylene glycol solution to system. Water used for dilution shall have a total hardness of less than 50 ppm, and a total chloride and sulfate of less than 25 ppm. Contractor shall assume that building potable water is/is not suitable, unless tested to prove otherwise.
- D. Perform tests determining strength of propylene glycol solution before system is turned over to the Owner. Provide test prior to end of the first year of operation and replenish as required.
- E. Set up glycol feeder control for proper operation. Set pressure switch to feed glycol to system at 12 psi.
- F. At time of substantial completion, glycol feeder shall be filled with a full tank of the proper solution.

END OF SECTION 15517

SECTION 15535 - REFRIGERATION SPECIALTIES

PART 1 GENERAL:

1.1 WORK INCLUDED:

- A. Liquid indicators.
- B. Strainers.
- C. Refrigerant driers.
- D. Filter-driers.
- E. Solenoid valves.
- F. Expansion valves.
- G. Refrigerant charging valves.
- H. Flexible connections.

1.2 REQUIREMENTS OF REGULATORY AGENCIES:

- A. Comply with applicable regulations.

1.3 SUBMITTALS:

- A. Submit shop drawings and product data in accordance with Section 15010. [.]
- B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Liquid Indicators
 - 1. ITT Fluid Handling Division
 - 2. Fisher and Porter
 - 3. Miriam Instrument Co.
- B. Strainers
 - 1. Automatic Switch Co.
 - 2. Mueller Brass Co.
- C. Refrigerant Dryers
 - 1. AMF Cuno Div.
 - 2. Mueller Brass Co.
- D. Filter Dryers
 - 1. AMF Cuno Div.
 - 2. Mueller Brass Co.
- E. Solenoid Valves
 - 1. Automatic Switch Co.
 - 2. Barber-Colman Co.
 - 3. Honeywell Co.

F. Expansion Valves

1. Sporlan Valve Co.
2. The Singer Co.

G. Charging Valves

H. Flexible Connectors

1. Aeroquip Corp.
2. Flexonic Div.
3. Thermotech Corp.

I. Substitutions: Items of same function and performance are acceptable in conformance with Section 15010. []

2.2 LIQUID INDICATORS:

- A. Double port type with copper or brass body, and flared or solder ends.
- B. Provide removable seal caps on each port for inspection of refrigerant condition.
- C. Provide full size liquid indicators in main liquid line leaving condenser. If receiver is used, install in liquid line leaving receiver.

2.3 STRAINERS:

- A. Angle type with brass shell and replaceable cartridge.
- B. Suitable for refrigerant and piping material utilized in the system.
- C. Provide full size strainer ahead of each automatic valve. Where multiple expansion valves with integral strainers are used, install single main liquid line strainer.
- D. On steel piping systems provide strainer in suction line to remove scale and rust.
- E. Provide shut-off valve on each side of strainer to facilitate maintenance.

2.4 REFRIGERANT DRIERS:

- A. In-line or angle type with copper or brass shell.
- B. Provide replaceable desiccant drier material.
- C. Provide full flow permanent refrigerant drier in low temperature systems and systems utilizing hermetic compressors.
- D. Provide three-valve by pass assembly.

2.5 FILTER-DRIERS:

- A. Angle type, with brass shell and using combined straining and drying material.
- B. Employ replaceable desiccant material.
- C. Acceptable in lieu of separate strainers and driers.
- D. Provide three-valve by pass assembly.

2.6 SOLENOID VALVES:

- A. Copper or brass body with flared or threaded ends.
- B. Use replaceable coil assembly.
- C. Provide a manually operated stem to permit operation in case of coil failure.
- D. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

2.7 EXPANSION VALVES:

- A. Angle type or straight through design suitable for the refrigerant utilized in the system.
- B. Brass body, internal or external equalizer, and adjustable superheat setting, complete with capillary tube and remote sensing bulb.
- C. Size expansion valves to avoid being undersized at full load and excessively oversized at partial load.
- D. Evaluate refrigerant pressure drop through system to determine the available pressure drop across each valve.
- E. Select valves for maximum load at design operating pressure and minimum 43 degrees F (6 degrees C) of superheat.

2.8 CHARGING VALVES:

- A. General purpose type with brass body, flared or solder ends, and removable valve core.
- B. Provide valve inlet with quick coupling connection for ease of charging.
- C. Provide refrigerant charging connections in liquid line between receiver shut-off valve and expansion valve.

2.9 FLEXIBLE CONNECTORS:

- A. Close pitch corrugated bronze hose with single layer of exterior braiding.
- B. At least 9 inches (229 mm) long with bronze fittings.
- C. Utilize only at or near compressors where it is not physically possible to absorb vibration within piping configuration.

PART 3 EXECUTION

3.1 INSTALLATION:

- A. Install refrigeration specialties in accordance with manufacturer's instructions.

3.2 REFRIGERANT DRIERS:

- A. Mount drier vertically in liquid line adjacent to receiver with bypass assembly to permit isolation of drier for servicing.

3.3 FILTER DRIERS:

- A. Install with bypass assembly to permit isolation for servicing.

3.4 EXPANSION VALVES:

- A. Locate expansion valve sensing bulb immediately after evaporator outlet on suction line.

END OF SECTION 15535

SECTION 15540 - HVAC PUMPS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of HVAC pumps work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Pumps furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-15 sections.
- C. Refer to other Division 15 sections for other work; not work of this section.
- D. Refer to Division-16 sections for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
 - 2. Interlock wiring between pumps; and between pumps and field-installed control devices.
 - a. Interlock wiring specified as factory-installed is work of this section.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and pump control panels.
 - a. Control wiring specified as work of Division-15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of general-use centrifugal pumps with characteristics, sizes and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI "Hydraulic Institute Standards".
 - 2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 778 "Motor Operated Water Pumps".
 - 3. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.
- C. Certification, Pump Performance: Provide pumps whose performances, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.
- B. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to HVAC pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- C. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 15.
- D. Maintenance Data: Submit maintenance data and parts lists for each type of pump, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 15.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING:

- A. Handle HVAC pumps and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged HVAC pumps or components; replace with new.
- B. Store HVAC pumps and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading HVAC pumps, and moving them to final location.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. In-Line Booster Pumps:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett ITT; Fluid Handling Div.
 - c. Amtrol
 - d. Taco
 - 2. In-Line Circulator Pumps:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett ITT; Fluid Handling Div.
 - c. Amtrol.
 - d. Taco
 - 3. Vertical In-Line Pumps:
 - a. Armstrong Pumps, Inc.
 - b. Amtrol.
 - c. Bell & Gossett ITT; Fluid Handling Div.

- d. Peerless Pumps
 - e. Taco
4. Frame-Mounted End Suction Pumps:
- a. Armstrong Pumps, Inc.
 - b. Amtrol.
 - c. Bell & Gossett ITT; Fluid Handling Div.
 - d. Allis Chalmers
 - e. Taco
 - f. Peerless Pumps
- 2.2 PUMPS:
- A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.
 - B. Pump motor shall be sized so as not to be overloaded at any point along impeller curve for specified performance.
 - C. All pump couplers shall be suitable for both constant speed and variable speed operation.
- 2.3 IN-LINE BOOSTER PUMPS:
- A. General: Provide in-line booster pumps where indicated, and of capacities as scheduled.
 - B. Type: Horizontal, oil-lubricated, designed for 125 psi working pressure, 225 degrees F (107 degrees C) continuous water temperature, and specifically designed for quiet operation.
 - C. Body: Cast iron, split vertical volute, rated for 175 psi, flanged suction and discharge.
 - D. Impeller: Steel shaft with copper or stainless steel shaft sleeves.
 - E. Shaft: Steel, ground and polished, integral thrust collar.
 - F. Bearings: Two horizontal sleeve bearings designed to circulate oil.
 - G. Seal: Mechanical, with carbon seal face rotating against ceramic seat.
 - H. Motor: Pump motor shall be non-overloading at any point on pump curve and meet the requirements of Section 15040.
 - I. Coupling: Self-aligning, flexible coupling.
- 2.4 IN-LINE CIRCULATOR PUMPS:
- A. General: Provide bronze fitted in-line circulator pumps where indicated, and of capacities as scheduled.
 - B. Type: Horizontal mount, vertical split case, oil-lubricated, designed for 175 psi working pressure, and 225 degrees F (107 degrees C) continuous water temperature.
 - C. Body: Cast iron, with flanged suction and discharge and gauge tapings.
 - D. Shaft: Hardened alloy steel.
 - E. Bearings: Oil-lubricated bronze journal bearings.
 - F. Seal: Mechanical, with carbon seal ring and ceramic seat.
 - G. Motor: Pump motor shall be non-overloading at any point on pump curve and meet requirements of Section 15040.
 - H. Coupling: Self-aligning, flexible coupling.
 - I. Impeller: Brass or Bronze enclosed type, hydraulically and dynamically balanced, and keyed to shaft.

2.5 VERTICAL IN-LINE PUMPS:

- A. General: Provide bronze fitted vertical in-line pumps where indicated, and of capacities as scheduled.
- B. Type: Vertical mount, in-line, close-coupled, single stage, designed for 175 psi working pressure.
- C. Body: Cast iron, 125/250 psi ANSI flanges of equal size, tappings for gauge and drain fittings.
- D. Shaft: Steel with replaceable shaft sleeve.
- E. Seal: Mechanical seal with ceramic seal seat.
- F. Motor: Pump motor shall be non-overloading at any point on pump curve, open and meet requirements of Section 15040.
- G. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw. Assembly components shall be 304 stainless steel.

2.6 FRAME-MOUNTED END SUCTION PUMPS:

- A. General: Provide frame-mounted bronze fitted end suction pumps where indicated, and of capacities and having characteristics as scheduled.
- B. Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 psi working pressure.
- C. Casing: Cast iron, 125 psi ANSI flanges, tappings for gauge and drain connections.
- D. Shaft: Steel with replaceable shaft sleeve.
- E. Bearings: Regreaseable ball sleeve bearings.
- F. Seal: Mechanical, with carbon seal ring and ceramic seat.
- G. Motor: Pump motor shall be non-overloading at any point on pump curve and meet requirements of Section 15040.
- H. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw. Assembly components shall be 304 stainless steel.
- I. Baseplate: Structural steel with welded cross members, and open grouting area.
- J. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.

PART 3 EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which HVAC pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PUMPS:

- A. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

- B. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.
- C. Support: Install base-mounted pumps [with inertia base] on minimum of 4" high concrete base equal or greater than 3 times total weight of pump and motor, with anchor bolts poured in place. Set and level pump, grout pump base with non-shrink grout.
 - 1. Install in-line pumps, supported from piping system.
- D. Support: Refer to Division-15 section "Vibration Control" for support and mounting requirements of HVAC pumps.
 - 1. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
- E. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- F. Piping Connections: Refer to Division 15 Section 15055 piping section. Provide system return connection to inlet strainer with valved bypass to drain. Provide pump discharge connections with check valve, shutoff valve, and balancing valve for each pump.

3.3 ADJUSTING AND CLEANING:

- A. Alignment: Adjust shafts of all motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
- B. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.
- C. Refer to Division 15, section 15990, for pump system balancing; not work of this section.
- D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 15540

SECTION 15570 - BOILER ACCESSORIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of boiler accessories work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Refer to other Division 15 sections for boilers, piping; piping specialties; control; pump; safety and pressure relief valves; water treatment; etc., required for installation of boiler accessories.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of boiler accessories, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ASME Compliance: Construct and install boiler accessories in accordance with ASME "Boiler and Pressure Vessel Code". Install boiler accessories in accordance with ASME B31.1 "Power Piping", or ASME B31.9 "Building Services Piping", as applicable.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating weights (shipping, installed, and operating where applicable), furnished specialties and accessories; and installation and start-up instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit ladder-type wiring diagrams for electrically operated boiler accessories. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 1 and 15.
- E. Maintenance Data: Submit maintenance data and parts lists for each boiler accessory, including "troubleshooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of Divisions 1 and 15.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Boiler Valves:
 - a. Crane Co.; Valves and Fittings Div.
 - b. Hammond
 - c. Jenkins Bros.

- d. Lunkenheimer (The) Co.; Div. of Conval Corp.
- e. Powell (The Wm.) Co.
- f. Walworth Co.

2. Pressure Relief Valves (Water):

- a. Amtrol, Inc.
- b. Bell & Gossett ITT.
- c. Spirax Sarco Co.
- d. Watts Regulator Co.

2.2 BOILER VALVES:

- A. General: Provide factory-fabricated boiler valves recommended by manufacturer for use in service indicated. Provide boiler valves of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, with connections which properly mate with pipe, tube, and equipment connections.
- B. Stop and Check Valves: Construct body of cast iron, ASTM A 126, Grade B, pressure rated for 250 PSI at 450 degrees F (232 degrees C) steam. Provide OS&Y construction, straight or angle pattern with flanged ends, and renewable bronze disc and seat ring.
- C. Y-Type Blowdown Valves: Construct body of bronze, ASTM B 62, pressure rated for 150 PSI steam. Provide Y-type globe construction, bronze seat ring, renewable composition disc, screw-in bonnet, and threaded ends.
- D. Y-Type Blowdown Valves: Construct body of bronze, ASTM B 62, pressure rated for 300 PSI steam. Provide Y-type globe construction, bronze seat ring, renewable composition disc, screw-in bonnet, threaded ends.

2.3 SAFETY AND RELIEF VALVES:

- A. Water Relief Valves: Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, constructed in accordance with ASME Boiler and Pressure Vessel Code.
 - 1. Pressure Relief Valves: Construct of bronze body, metallic disc, metal seat, with nonmechanically guided stem. Set valve to relieve at 10 PSI above operating pressure.

PART 3 EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which boiler accessories are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BOILER ACCESSORIES:

- A. Install boiler accessories as indicated, in accordance with manufacturer's installation instructions, and with recognized industry practices, to ensure that boiler accessories comply with requirements and serve intended purposes. Comply with requirements of state and local boiler codes, applicable portions of ASME Boiler and Pressure Vessel Code, and applicable portions of ASME B31.1 or ASME B31.9.

- B. Coordinate with other work as necessary to interface installation of boiler accessories with other components of heat generation systems.

3.3 BOILER VALVES:

- A. Stop-and-Check Valves: Install as indicated on top of boiler steam nozzles. Install additional chain operated stop valve between stop-and-check valve and boiler header.
- B. Y-Type Blowdown Valves: Install as indicated on blowdown piping. Connect discharge to blowdown separator. Install additional stop valve between blowdown valve and boiler.

3.4 SAFETY AND RELIEF VALVES:

- A. Water Relief Valves: Install as indicated on top of boilers. Pipe discharge to floor drain.

3.5 FIELD QUALITY CONTROL:

- A. Flush and clean boiler accessories upon completion of installation, and in accordance with manufacturer's installation instructions.
- B. Hydrostatically test, if required, assembled boiler accessories and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.

END OF SECTION 15570

SECTION 15575 BREECHINGS, CHIMNEYS, AND STACKS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

- A. This Section specifies double wall metal vents and accessories for gas-fired appliances.
- B. This Section specifies refractory lined metal breechings, chimneys, and accessories.
- C. This Section specifies field fabricated metal breechings, chimneys, and accessories.

1.2 SUBMITTALS:

- A. Product Data: Submit product data including materials, dimensions, weights, sizing, and accessories.
- B. Shop Drawings: Submit shop drawings including required clearances, assembly and installation instructions, and support of components.
 - 1. The Sheet Metal Contractor shall submit a computerized vent sizing analysis for the actual boilers and water heaters being furnished. The computer analysis shall list the make, model number, firing rate, and the allowable back pressure for each appliance, the quantity and type of each component, the draft conditions with each appliance firing individually and with all appliances firing. The Contractor shall also provide drawings showing all components and their location in the system.

NOTE:

- a. All parts exposed to outside atmosphere shall be coated by the installer, with one base coat and one finish coat of Glidden, Metallite, or approved equal.
- b. In lieu of painting all exposed parts, a 304 SS or 316 SS outer may be specified.

C. Quality Control Submittals:

- 1. Certificates: Submit certificates of materials compliance with specified ASTM, UL, and ASHRAE requirements.
- 2. Certificates: Submit Welders' Qualification Certificates.
- 3. Certificates: Submit complete engineering report certifying that stacks meet the design wind and seismic loads.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 15.

1.3 QUALITY ASSURANCE:

- A. Welder's Qualifications: All welders shall be certified in accordance with AWS Standard D9.1, Specifications for Welding Sheet Metal.
- B. Codes and Standards:
 - 1. NFPA: Comply with NFPA 211 "Standard for Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances."

2. UL: Comply with applicable portions of UL safety standards; provide products which have been UL listed and labeled.
3. SMACNA: Comply with SMACNA Low Pressure Duct Standards for fabricated breeching and smokepipe.
4. AWS: Comply with AWS Structural Welding Code for welders' qualifications, welding details, and workmanship standards.
5. ASHRAE: Comply with the ASHRAE Equipment Handbook, Chapter 27, for Chimney, Gas Vent, and Fireplace Systems, material requirements and design criteria.
6. UMC: Comply with I.A.P.M.O. Uniform Mechanical Code for chimney application and requirements of stack type, height and clearances.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

A. Double Wall Metal Vents:

1. American Metal Products Co.; Div. of Masco Corp.
2. General Products Co., Inc.
3. Hart & Cooley Mfg. Co.
4. Selkirk Metalbestos.
5. Simpson Dura-Vent.

B. Refractory Lined Metal Breechings and Chimneys:

1. Power Pac Enterprises, Ltd.
2. Susquehanna Concrete Products, Inc.
3. Van-Packer Co.
4. Stacks, Inc., Div of Air Management, Inc.

C. Fabricated Metal Breechings and Chimneys:

1. American Metal Products Co.; Div. of Masco Corp.

2.2 DOUBLE WALL METAL VENTS:

A. Type B Gas Vents (Gas-Burning Appliances Only):

1. Description: Double wall gas vents, UL listed for Type B, consisting of an inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, with the following minimum thicknesses:

<u>Size</u>	<u>Inner Pipe</u>	<u>Outer Pipe</u>
Round, up to 6"	0.012"	28 gauge
Round, 7" to 18"	0.014"	28 gauge
Round, 20" to 24"	0.018"	26 gauge
Oval, up to 4"	0.012"	28 gauge
Oval, 5" to 6"	0.014"	28 gauge

2. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners, fabricated of similar materials and designs as vent pipe straight sections.

B. All Steel, Positive Pressure, Double and Triple Wall Vents:

1. Description: UL-labeled double and triple wall metal stacks for use with building heating equipment burning gas, solid, or liquid fuels not exceeding 1000 degrees F. continuous and capable of maintaining airtight integrity at pressures up to 72inches W.C. as described in NFPA 211 and UL 103.
2. Construction: All stacks and breechings will have inner walls of 20 ga. (Type 304 Stainless Steel for gas and No. 2 Oil) or (Type 316 Stainless Steel for solid fuels, or No. 4 thru No. 6 Oil). The outer jacket shall be 24 ga. aluminum coated steel for sizes up to 24inches I.D. and 20 ga. for sizes 26inches I.D. and larger. There shall be minimum 1" air space between the inner and outer walls.
3. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners fabricated of similar materials and designs as vent pipe straight sections.

2.3 REFRACTORY LINED METAL BREECHINGS AND CHIMNEYS:

A. Design Loads:

1. Wind Loading: 110 mph.
2. Seismic Loading: Zone 1.

B. Steel Jacket:

1. Chimney Outer Jacket:
 - a. 26 gauge aluminized steel with riveted seams.
 - b. 11 gauge galvanized steel with welded seam joint.
2. Breeching Outer Jacket: 11 gauge galvanized steel with welded seams.

C. Refractory Lining:

1. Tested under UL Standard 959 for temperature and acid resistance, and bearing the testing laboratory label.
2. Temperature: Withstand 1800 degrees F continuous firing, and 2000 degrees F intermittent firing without fusion.
3. Acid Extraction: Maximum of 0.2 percent.
4. Cold Crushing Strength: Minimum of 3,200 psi.
5. Bond refractory lining to steel jacket so finished product may be shipped, handled, and installed with no separation.
6. Thickness: Minimum of 2inches.

7. Finishing: Factory-applied, high heat resistant paint, color as selected by the Architect/Engineer.

D. Accessories: Provide accessories bearing UL label.

1. Base Section: Provide acid resistant coated cast-iron anchor lugs for securing stack to foundation.
2. Cleanout Section: Provide smoke-tight cleanout section with gasketed and bolt-tightened inspection plate. Weld neck to stack section.
3. Tee or Wye Section: smoke-tight tee or wye as indicated for breeching connection, with welded joints, refractory lining, finished with smooth transition, and with no exposed metal on inside.
4. Spark Screen: Type 304 stainless steel, 16 gauge, 1/2 x 1/2 inches mesh, with Type 304 stainless steel rolled angle and drawband.
5. Guy bands: 8inches wide bands of same material as jacket, fastened with nuts and bolts for tight fit.
6. Roof Penetration: factory fabricated thimble, flashing, and counterflashing.

E. Fabrication:

1. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.
2. Fabricate components with centrifugally cast lining in lengths suitable for connection with drawband. Bond refractory with calcium aluminate cement.
3. Fabricate chimneys with anchor lugs, cleanout, T- sections, flashing and counterflashing, and provisions for support, expansion, and contraction.
4. Fabricate breechings with support lug for attachment to building structure so as not to exceed permissible loading at appliance and chimney.

2.4 FABRICATED METAL BREECHINGS AND CHIMNEYS:

A. Materials:

1. Black, carbon, hot-rolled steel complying with ASTM A 569, except breechings less than 24inch diameter (or longest side) may be galvanized sheet steel complying with ASTM A 527, lock forming quality with ASTM A 525, G90 zinc coating, mill phosphated.
2. Minimum gauges for corresponding sizes as indicated (diameter or longest side dimension):

<u>SIZES</u>	<u>THICKNESS - Gauge</u>
up to 12"	18
13" to 24"	16

B. Fabrication:

1. Shop fabricate breechings and chimneys in as complete as possible to minimize field welding. Match-mark sections for field assembly and coordination of installation.
2. Longitudinal Seams: welded, except longitudinal seams for breechings less than 24inches diameter (or longest side) may be Acme grooved type.
3. End joints: weld, lap and bolt, or use companion flanges; except breechings less than 24inches diameter (or longest side) may have end joints beaded and crimped.
4. Reinforcement: Reinforce rectangular breechings with angle frames as follows for corresponding long side dimensions; and reinforce round breechings with either flanged girth joints or angle frames as follows for corresponding diameter:

<u>SIZES</u>	<u>REINFORCING</u>	<u>INTERVAL</u>
up to 30"	No reinforcing required.	

5. Fabricate breeching and chimneys fittings to match adjoining materials. Except as otherwise indicated, fabricate elbows with centerline radius equal to associated breeching width. Limit angular tapers to 20 degrees maximum for expanding tapers. Install accessories during fabrication to greatest extent possible.

C. Accessories and Specialties:

1. Provide accessories and specialties of types and sizes required to comply with breeching requirements including proper connection of equipment.
2. Barometric Dampers: adjustable, self-actuating draft dampers, where indicated, full size of breeching.
3. Cleanout Doors: same gauge as breeching; size and location as indicated.
4. Thermally Actuated Vent Dampers: same size as draft hood collar; constructed of stainless steel housing and brackets. Secure 4 quadrants to brackets constructed of corrosion resistant bi-metal. Secure brass weights to quadrants to prevent vibrations and noise during high draft conditions. Test units in accordance with AGA standards, and certify design complies with ANSI Z21.68.

PART - 3 EXECUTION

3.1 INSTALLATION OF DOUBLE WALL CONNECTORS, BREECHINGS AND VENTS:

- A. Install Type B gas vents in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.
- B. Install all steel, positive pressure, double and triple wall gas vents in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing. The system shall have a 10 inch minimum clearance to combustibles with flue gases not exceeding 1000 degrees F. continuous.
- C. Seal joints between sections of positive pressure vents in accordance with manufacturer's installation instructions, and using only sealants recommended by manufacturer. The inner pipe joints shall be field sealed with Containment Bands and high temperature sealant.

- D. Support vents at intervals recommended by the manufacturer to support the weight of the vent and all accessories, without exceeding loading of appliances. Stacks extending above the roof must terminate a minimum of 3feet-0inches above the roof or parapet per NFPA 211, or as required by local code.
 - E. Provide guy wire support of roof stacks in accordance with manufacturer's recommendations.
- 3.2 INSTALLATION OF REFRACTORY LINED BREECHINGS AND CHIMNEYS:
- A. Assemble and erect stack sections and accessories in accordance with the manufacturer's written instructions and in compliance with UL listing. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
 - B. Joints:
 - 1. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
 - 2. Weld joints. Comply with the workmanship quality standards specified in AWS D9.1, Specifications for Welding of Sheet Metal.
 - C. Erect chimneys level and plumb to finished tolerance of no more than 1inch out of plumb from top to bottom.
 - D. Erect breechings with a slope down to appliance, with condensate drain connection. Pipe drain line to nearest open site drain.
 - E. Field painting is specified in Division 9 including touch- up or refinishing sections or accessories that are scratched or marred during shipping and handling, or require touch-up after welding.
- 3.3 INSTALLATION OF FABRICATED BREECHINGS AND CHIMNEYS:
- A. Assemble and erect fabricated breechings and chimneys in accordance with SMACNA Low Pressure Duct Construction Standards.
 - B. Joints: Weld joints in conformance with AWS workmanship standards of AWS D 9.1, Specification for Welding Sheet Metal.
 - C. Align breechings accurately at connections, with a smooth internal surface and a 1/8inch misalignment tolerance.
 - D. Slope breechings down to appliances and provide a condensate drain connection. Pipe drain line to nearest open site drain.
 - E. Install concrete inserts for support of breeching in coordination with formwork.
 - F. Install accessories, dampers, fans, equipment, controls, and other supports.
 - G. Anchor breechings to building structure with bolts, concrete inserts, steel expansion anchors (not lead-shield type), welded studs, C-clamps or special beam clamps.
 - H. Vertical Breechings:
 - 1. Support at 12 foot intervals, by attachment to adjacent vertical structural surfaces or by direct bearing at floor penetrations and similar locations.

2. Breechings up to 24inch x 20inch: use 1-1/2inch x 16 gauge straps or formed angles.
 3. Breechings larger than 24inch x 20inch: use steel angle brackets 1inch x 1/8inch for sizes up to 36inch x 18inch; 1-1/2inch x 1/8inch for larger sizes.
- I. Horizontal breechings located against structural walls and other similar adjacent vertical surfaces:
1. Support at 8 foot intervals for units up to 40inch horizontal dimensions, and 4 foot intervals for larger breechings.
 2. Where width is less than height: support with 1-1/2inch x 16 gauge straps.
 3. Where width is more than height: support with shelf- type fabricated angle brackets; 1" x 1/8" for widths up to 18inches; 1-1/2inch x 1/8inch for greater widths.
- J. Horizontal Rectangular Breechings:
1. Support from overhead structure with hangers at 10 foot intervals for unit widths up to 60inches, and 8 foot intervals for larger breechings.
 2. Support breechings directly with 1inch x 16 gauge straps up to 60inches width, and with 1-1/2inch x 12 gauge straps up to 96inch width, bolted to breechings.
- K. Trapeze Hangers:
1. Support breechings with horizontal angle members and vertical support members of sizes listed below (long side dimensions):
 - a. Up to 30 inches size: 1inch x 1/8inch angle, with 1inch x 18 gauge or 1/4inch diameter hangers.
 - b. 31inches to 60 inches size: 1-1/2inch x 1/8inch angle, with 1-1/2inch x 16 gauge or 3/8inch diameter hangers.
 - c. 61inches to 84inches size: 2inch x 1/8inch angle, with 1-1/2inch x 14 gauge or 1/2inch diameter hangers.
 - d. Over 84 inches size: 2inch x 1/4inch angle, with 5/8inch diameter hangers, except as otherwise shown.
- L. Horizontal Round Breechings:
1. Support with girth strap and strap hanger (of same size); except for sizes over 50inches in diameter. Install pair of strap hangers bolted to opposite sides of angle reinforcing rings or flanged joints. Support breechings at 10 foot intervals with hangers as follows for corresponding diameters.
 - a. Up to 30inch diameter: 1inch x 16 gauge strap hangers.
 - b. 31inches to 50inches diameter: 1-1/2inch x 16 gauge strap hangers.
 - c. 51" to 84" diameter: Pairs of 1-1/2inch x 16 ga
 - d. hangers.

3.4 INSTALLATION OF DAMPERS:

- A. Install barometric and thermostatically operated dampers in accordance with manufacturer's instructions. Locate as close to draft hood collar as possible.

3.5 ADJUSTING AND CLEANING:

- A. Clean breechings internally during installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.

3.6 PROTECTION:

- A. Temporary Closure: At ends of breechings and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until installations are completed.

END OF SECTION 15575

SECTION 15670 CONDENSING UNITS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Section includes:

1. Air-cooled condensing units.

B. Manufacturers shall be responsible to provide any information to the contractor prior to bidding which may impact the installed cost for the contractor including but not limited to:

1. Power wiring sizing, quantity and type of conductors and terminations requirements.
2. Control Power.
3. Auxiliary piping connections.

1.2 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants & environmentally friendly.

B. No CFC based refrigerants shall be used.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), dimensions, required clearances, and methods of assembly of components, furnished specialties and accessories; and installation and start-up instructions.

B. Wiring Diagrams: Submit ladder-type wiring diagrams for power and control wiring required for final installation of condensing units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

C. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 15.

D. Maintenance Data: Submit maintenance data and parts list for each condensing unit control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of Division 15.

E. Operation and Maintenance Data: Submit maintenance data and parts list for each condensing unit, control, and accessory; including "trouble shooting" maintenance guide; plus servicing, and preventative maintenance procedures and schedule. Include this data and product data in maintenance manual; in accordance with requirements of Division 15.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of condensing units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Capacity ratings for condensing units shall be in accordance with ARI Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment" and all other ARI standards applicable to the specific equipment as applicable.
2. Refrigeration system of condensing units shall be constructed in accordance with ASHRAE Standard ASHRAE 15 "Safety Code for Mechanical Refrigeration".
3. Condensing units shall meet or exceed the minimum COP/Efficiency levels as prescribed in ASHRAE 90A "Energy Conservation in New Building Design".
4. Construction and testing of water cooled condensing units shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.
5. Condensing units shall be listed by UL and have UL label affixed.
6. Unit construction shall comply with ANSI safety codes.
7. Unit construction shall comply with the National Electrical Code.

1.5 DELIVERY, STORAGE, AND HANDLING:

- A. Handle condensing units and components carefully to prevent damage. Follow manufacturer's written instructions for rigging. Replace damaged condensing units or components.
- B. Store condensing units and components in clean dry place off the ground. Protect from weather, water, and physical damage.

1.6 SPECIAL PROJECT WARRANTY:

- A. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

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

1. Air-Cooled Condensing Units:
 - a. McQuay Air Conditioning Group; McQuay Inc.
 - b. Trane (The) Co; Div American Standard Inc.
 - c. York; Div of York International.

2.2 AIR-COOLED CONDENSING UNITS:

- A. General: Factory-assembled and tested air-cooled condensing units, consisting of casing, compressors, condensers, coils, condensing coil guard, condenser fans and motors, and unit controls.

- B. Unit Casings: Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include:
1. Steel, galvanized or zinc-coated, for exposed casing surfaces, treated and finished with manufacturer's standard paint coating;
 2. Lifting lugs to facilitate rigging of units;
 3. Factory-installed metal grilles, for protection of condenser coil during shipping, installation, and operation;
 4. Hinged and gasketed control panel door.
- C. Compressor: Reciprocating hermetic-type compressor, 1,750 RPM, designed for air-cooled condensing, complete with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports. Capacity shall be controlled through cylinder unloading. Additional features include:
1. Crankcase heater in well within crankcase;
 2. Capacity steps as scheduled, or greater number;
 3. Compressor of same manufacturer as condensing unit.
- D. Controls: Operating and safety controls shall include high and low pressure cutouts, oil pressure cutout, compressor winding thermostat cutout, 3-leg compressor overload protection, and condenser fan motors with thermal and overload cutouts. Control transformer if required shall be 115-volts. Provide magnetic contactors for compressor and condenser fan motors. Additional features include:
1. Reset relay circuit for manual resetting of cutouts from remote thermostat location;
 2. Automatic nonrecycling pumpdown, and timing device to prevent excessive compressor cycling;
 3. Unfused disconnect switch, factory-mounted and wired, for single external electrical power connection.
 4. Compressor shall be located in a section separated from condenser fans and coils.
 5. Compressor shall be mounted on spring isolators.
 6. Compressor shall be provided with hot gas bypass
- E. Condensing Section: Condenser coil shall be seamless copper tubing mechanically bonded to heavy-duty, configurated aluminum fins, with separate and independent refrigeration circuit for each compressor. Units shall include liquid accumulator and subcooling circuit, and backseating liquid line service access valve. Condenser coils shall be factory-tested at 450 psig, vacuum dehydrate, and filled with a holding charge of nitrogen.
- F. Condenser fans and drives: propeller-type condenser fans for vertical air discharge; either direct drive or belt drive. Additional features include:
1. Permanent lubricated ball bearing condenser fan motors;
 2. Separate motor for each condenser fan;
 3. Constant speed condenser fan motors;

4. Each fan assembly shall be dynamically and statically balanced.
- G. Low ambient head pressure control: Factory-installed low ambient damper assembly, fan speed control, or fan cycling control for operation down to -20 degrees F.

PART 3 EXECUTION

3.1 EXAMINATION:

- A. Verify roof structure, mounting supports, and membrane installations are completed to the proper point to allow installation of roof mounted units. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. General: Install condensing units in accordance with manufacturers installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
 1. Provide flexible connections on all piping connections.
- B. Install ground-mounted units on 4inch thick reinforced concrete pad, 4inches larger on each side than condensing unit. Concrete is specified in Division 3. Coordinate installation of anchoring devices.
- C. Install roof-mounted units on equipment supports on roof curbs with water proof flashing. Anchor unit to supports with removable fasteners.
- D. Air-Cooled Condensing Units: Connect refrigerant piping to unit; maintain required access to unit.
 1. Install furnished field-mounted accessories.

3.3 FIELD QUALITY CONTROL:

- A. Testing: Test unit when field piping is completed through all phases of operation after pressure tests have been completed in compliance with Division 15 specification.
- B. Charge systems with full charge of refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
 1. Install core in filter dryer after leak test, but before evacuation.
 2. Evacuate refrigerant system with vacuum pump until 35 degrees F is indicated on vacuum dehydration gauge.

3.4 DEMONSTRATION:

- A. Provide services of manufacturer's authorized service representative to provide factory 1start-up service and to instruct Owner's personnel in operation and maintenance of condensing units.
- B. Start-up condensing units, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

- C. Train Owner's personnel on start-up and shut-down procedures, troubleshooting procedures, servicing, and preventative maintenance schedule and procedures. Review with the Owner's personnel, the data contained in the Operating and Maintenance Manuals specified in Division One.

3.5 TRAINING:

- A. Schedule a minimum of 4 hours of training with Owner. The manufacturers representative, and the Division 15 contractor shall be present. The training shall be coordinated by the Division 15 contractor and the Owner in conjunction with the other mechanical equipment on the project.
- B. Training:
 - 1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in Division 1 and Section 15010.
 - 2. Schedule training with Owner through the Architect/ Engineer with at least 7 days prior notice.

END OF SECTION 15670

SECTION 15683 - RECIPROCATING/SCROLL CHILLERS

PART 1- GENERAL

1.1 REFRIGERANTS:

- A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants & environmentally friendly.
- B. No CFC based refrigerants shall be used.

1.2 DESCRIPTION OF WORK:

- A. Extent of reciprocating/scroll liquid chiller work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of reciprocating/scroll liquid chillers specified in this section include the following:
 - 1. Packaged outdoor air-cooled.
- C. Refer to other Division-15 sections for concrete pads, piping, piping specialties, pumps, and valves, which are required external to reciprocating chillers for installation.
- D. Refer to other Division-15 sections for field-installed automatic temperature controls required in conjunction with reciprocating chillers.
- E. Refer to Division-15 section "Vibration Control" for vibration control work required in connection with reciprocating chillers.
- F. Manufacturers shall be responsible to provide any information to the contractor prior to bidding which may impact the installed cost for the contractor including but not limited to:
 - 1. Power wiring sizing quantity and type of conductors.
 - 2. Control Power.
 - 3. Auxiliary piping connections.

1.3 QUALITY ASSURANCE:

- A. Manufacturers: Firms regularly engaged in manufacture of reciprocating chillers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 5 years of successful installation experience with projects utilizing reciprocating chillers similar to those required for this project.
- C. ARI Compliance: Test and rate reciprocating chillers in accordance with ARI Std 590, "Standard for Reciprocating Water-Chilling Packages."
- D. ASHRAE Compliance: Construct and install reciprocating chillers in accordance with ASHRAE Std 15, "Safety Code for Mechanical Refrigeration". Provide Energy Efficiency Ratio (EER) for reciprocating chillers not less than prescribed by ASHRAE Std 90A, "Energy Conservation in New Building Design".
- E. NEC Compliance: Comply with applicable NEC requirements pertaining to electrical power and control wiring for construction and installation of reciprocating chillers.

- F. ANSI/ASHRAE Compliance: Comply with ANSI 15 safety code requirements pertaining to unit construction of reciprocating chillers.
 - G. ASME Compliance: Construct and test reciprocating air-cooled liquid chiller in accordance with ASME Boiler and Pressure Vessel Code, Section 8.
 - 1. Stamp cooler with ASME mark when cooler has been successfully tested in accordance with ASME Code. Pressure test cooler for refrigerant working side pressure of not less than 235 PSIG (1620 kPa), and water side pressure of not less than 150 PSIG (1034 kPa). Leak test cooled condenser coils at 150 PSIG (1034 kPa) and pressure test coils at 450 PSIG (3103 kPa).
 - H. NEMA Compliance: Provide high-efficiency motors for reciprocating chillers which comply with NEMA Stds Pub/No.'s MG 1, 2, 3, 10, and 11.
 - I. UL Compliance: Comply with applicable requirements of UL 465, "Central Cooling Air Conditioners", pertaining to construction and installation of reciprocating chillers. Provide reciprocating chillers, which are UL-listed and labeled.
 - J. ANSI/UL 984: Safety standards for hermetic motor compressors.
- 1.4 SUBMITTALS:
- A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. Provide description of alternative refrigerant including:
 - 1. Potential lifetime in years.
 - 2. Ozone depletion factor potential.
 - 3. Global warming potential.

The equipment provided shall provide the scheduled capacity when the substitute refrigerant proposed, the nominal equipment capacity reduction effects (if any), performance in KW/TON, the refrigerant change out procedure and long term maintenance effects the new refrigerant has on the equipment.
 - B. Product Data: Submit manufacturer's technical product data, including rated capacities for chillers indicated, sound power levels, weights (shipping, installed, and operating), furnished specialties and accessories; and rigging, installation, and start-up instructions.
 - C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field-connection.
 - D. Provide templates for anchor bolt placement in concrete pad. Deliver templates to concrete installer so work by others is not delayed.
 - E. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
 - F. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 1 and 15.

- G. Maintenance Data: Submit maintenance data and parts list for each reciprocating chiller, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of Divisions 1 and 15.

1.5 DELIVERY, STORAGE, AND HANDLING:

- A. Handle reciprocating chillers and components properly to prevent damage, breaking, denting and scoring. Do not install damaged reciprocating chillers or components; replace with new. Comply with manufacturer's rigging and installation instructions for unloading reciprocating chillers, and transporting them to final location.
- B. Store reciprocating chiller and components in clean dry space. Protect from weather, dirt, fumes, water, construction debris, and physical damage. Storage temperatures for unit controls are not to exceed 185 deg.F (85 deg.C).

1.6 WARRANTY:

- A. Provide (5) five year motor/compressor replacement warranty in addition to the 1 year warranty required under Section 15010. Warranty shall include parts and labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Outdoor Air-Cooled Scroll/Reciprocating Liquid Chillers:
 - a. Bohn Heat Transfer Div; Gulf + Western Mfg Co.
 - b. McQuay Group; McQuay-Perfex Inc.
 - c. Trane Company.
 - d. York Div; Borg-Warner Corporation.

2.2 OUTDOOR AIR-COOLED LIQUID CHILLERS:

- A. General: Provide factory-assembled and tested outdoor air-cooled reciprocating liquid chillers as indicated, consisting of compressors, evaporator, condensers, thermal expansion valves, and control panels. Provide capacity and electrical characteristics as scheduled.
- B. Refrigerant: Provide full operating charge of refrigerant and oil.
- C. Housing: Housing shall be minimum 14-gauge welded galvanized steel frame with 14 and 16 gauge galvanized steel panels and access doors with corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts and components.
- D. Evaporator: Provide shell-and-tube design with seamless copper tubes roller expanded into tube sheets. Design, test, and stamp for refrigerant side working pressure of 225 PSIG minimum, and water side working pressure of 150/300 PSIG minimum, in accordance with ASME Pressure Vessel Code. Provide one water pass with series of internal baffles. Insulate with 3/4" minimum flexible unicellular insulation with maximum K-value of 0.26. Provide water drain connection and bulb wells for temperature controller and low-temperature cutout.
 - 1. Heater Tapes: Provide electrical resistance heater tape on evaporator to protect against freezing at -20 deg.F (- 29 deg.C) ambient at no-flow condition.

2. Multiple-Compressor Units: Provide independent multiple refrigerant circuits with gasketed evaporator heads.
- E. Condenser: Construct coils with configured aluminum fins mechanically bonded to seamless copper tubing. Provide integral subcooling circuit with liquid accumulators. Leak test coils with air under water at 425 PSIG air pressure. Provide protective grilles over exposed coil faces.
1. Multiple-Compressor Units: Provide multiple circuited condenser coils.
 2. Condenser Fans: Provide propeller fans, direct or belt [] driven, draw-through design, statically and dynamically balanced. Provide permanently lubricated ball-bearing motors with overload protection. Provide protective grille over air discharge.
 3. Low Ambient Control: Provide head pressure control, designed to operate at temperatures down to [0] deg.F (-18 deg.C).
- F. Compressors: Provide direct drive 1750/3600 RPM, multicylinder scroll/reciprocating compressors with crankcase heater; either semi-hermetic or hermetic, with a minimum [] steps of capacity control, provided by cylinder unloading or compressor staging, or combination of both. Mount compressors on vibration isolators within chiller housing.
1. Lubrication: Provide oil pump, oil filter, oil level sight glass, and oil charging valve.
- G. Capacity Modulation: Provide step-control by means of cylinder unloading and/or compressor staging, from return water temperature.
- H. Refrigerant Circuit: Provide for each refrigerant circuit the following:
Provide multiple independent separate refrigerant circuits with a minimum of two.
1. Liquid line solenoid valve.
 2. Filter dryer.
 3. Liquid line sight glass and moisture indicator.
 4. Thermal expansion valve.
 5. Insulated suction line.
 6. Suction and discharge valves.
- I. Controls and Control Panels:
1. Locate on/near chiller, factory wired/NEMA 1 unit control panel, containing both a controls section as well as a starter section.
 2. Provide the following devices in starter section:
 - a. Top access for power wiring.
 - b. Factory wired single point power hook-up to terminal block. /unit mounted, non-fused disconnect switch.
 - c. Three-phase solid-state overload protection.
 - d. Customer wired grounding lug.
 - e. Control power transformer with primary and secondary fused protection.
 - f. Factory wired part winding/across-the-line starter with solid state fixed off/on timers on all compressor motors.
 - g. Non-recycling compressor overloads.

- h. Phase loss/reversal/imbalance and undervoltage monitor on main power connection. a 15% under voltage condition for 4-5 seconds will shut unit off and require manual reset.
3. Provide the following devices in the control panel:
 - a. Compressor run lights.
 - b. System start-stop switch.
 - c. Low pressure lockout lights.
 - d. Terminal strips.
 - e. Central micro-processor
 - 1) Leaving fluid setpoint.
 - 2) Delta T setpoint.
 - 3) # of stages.
 - f. Control power fuses.
 - g. Motor protection/oil failure controller.
 - h. Indicating lights for load limit.
 - i. Stages of unit unloading.
4. Provide the following safety controls arranged so that operating any one will shut down machine and require manual reset:
 - a. Low chilled water temperature switch.
 - b. High discharge pressure switch for each compressor.
 - c. Low suction pressure switch for each compressor.
 - d. Oil pressure switch.
 - e. Current overload.
 - f. Motor temperature.
5. Provide the following safety controls so there is automatic shutdown of the machine with automatic reset:
 - a. Over voltage.
 - b. Under voltage.
 - c. Phase reversal.
 - d. Chilled water flow interlock.
 - e. Condenser water flow interlock.
6. Provide the following operating controls:
 - a. Multi-step chilled water temperature controller, which cycles compressor and activates cylinder unloaders.
 - b. Five minute off timer prevents compressor from short cycling.
 - c. Part winding/Across-the-line solid state start timer.
 - d. Provide automatic circuit to circuit lead-lag capability to allow for equal run time per compressor.
 - e. Periodic pump-out timer to pump down on chilled water flow and high evaporator refrigerant pressure.
 - f. Load limit thermostat to limit compressor loading on high return water temperature.
 - g. Power supply monitor to protect unit by stopping compressor on phase loss, phase reversal, incorrect phase sequence, and low voltage.
 - h. Cycle counter and operating hour meter.

7. Provide pre-piped gauge board with pressure gauges for suction and discharge refrigerant pressures, and oil pressures for each compressor.
 8. Provide alarm package with test button and indicating lights which indicate control circuit is energized and compressor is running, and will sound an audible alarm and light an indicating light upon detection of compressor malfunction, low chilled water temperature, or evaporator water flow failure.
 9. Provide chilled water reset algorithm in the microprocessor that resets leaving water temperature based on [ambient] or [zone] temperature. Provide field installed sensor.
- J. Accessories: Provide the following accessories:
1. Hot gas bypass valve, factory-piped and wired.
 2. Load limit thermostat, if required.
 3. Vaporproof chilled water flow switch.
 4. Suction and discharge gages.
 5. Oil pressure gages except for hermetic compressors.
 6. Vibration isolators of the following type:
 - a. Spring isolators.
 - b. Equipment rails and vertically-restrained spring isolators.
 - c. Fabricated equipment base and spring isolators.
 7. Low ambient dampers for 0°F ambient start-up and run.
 8. Copper condenser fins.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Installer must examine areas and conditions under which reciprocating chillers are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF RECIPROCATING CHILLERS:

- A. General: Install reciprocating chillers in accordance with manufacturer's written instructions. Install units plumb and level, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
- B. Support: Install floor-mounted units on reinforced concrete pad. Furnish anchor bolts, which are to be inserted in concrete pad to Concrete Installer.
- C. Support: Install roof-mounted units on structural steel mechanical equipment stand. Anchor unit to stand with removable type fasteners.
 1. Construct mechanical equipment stand as indicated, and in accordance with NRCA Handbook of Accepted Roofing Knowledge, Detail "N".

2. Mechanical equipment stand is specified in Division 5; not work of this section.
- D. Chilled Water Piping: Refer to Division-15 section "Hydronic Piping". Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, flexible pipe connector, drain valve, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, flow meter, thermometer, flexible pipe connection, pressure gage, drain valve, and union or flange.
 - E. Condenser Water Piping: Refer to Division-15 section "Condenser Water Piping". Provide flanged or union connections to condenser, arranged to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, pressure gage, flexible pipe connector, and union or flange. Connect outlet to condenser with shutoff valve, flow meter, thermometer, drain valves and shutoff valve, strainer, plugged tee, flexible pipe connector, and union or flange.
 - F. Refrigerant Piping: Refer to Division-15 section "Refrigerant Piping". Provide piping between chiller and condenser as indicated, and in accordance with installation instructions of both chiller and condenser manufacturers.
 - G. Relief Piping: Provide relief piping as indicated from refrigerant pressure relief rupture disc on chiller to outside building atmosphere; size piping as recommended by chiller manufacturer, and terminate with gooseneck facing down.
 - H. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to manufacturer and equipment installer.
 - I. Control: Furnish field-installed automatic temperature control requirements to Control Installer.
 - J. Start-up: Chiller start-up shall be by factory authorized service representative in accordance with manufacturer's recommendations. Test controls and demonstrate compliance with requirements. Replace damaged, or malfunctioning, controls and equipment and retest.
 1. Do not place chillers in sustained operation prior to initial balancing of mechanical systems, which interface with the reciprocating chillers.
- 3.3 TRAINING OF OWNER'S PERSONNEL:
- A. Provide services of manufacturer's technical representative for two 8-hour days to instruct Owner's personnel in operation and maintenance of reciprocating chillers.
 1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 15683

SECTION 15830 - TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of terminal unit work is indicated on drawings and schedules, and by requirements of this section.
- B. Types of terminal units required for project include the following:
 - 1. Baseboard radiation.
 - 2. Finned tube radiation.
 - 3. Unit heaters.
 - 4. Cabinet unit heaters.
 - 5. Fan-coil units.
- C. Refer to other Division 15 sections for piping; ductwork; testing, adjusting and balancing of terminal units; not work of this section.
- D. Refer to Division 16/1 section for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on terminal units.
 - 2. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - a. Control wiring between field-installed controls, indicating devices, and terminal unit control panels.
 - 1) Control wiring specified as work of Division 15 for Automatic Temperature Controls is work of that section.
- E. Refer to other Division 15 sections for automatic temperature controls not factory installed, required in conjunction with terminal units; not work of this section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.
 - 2. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".
 - 3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
 - 4. ARI Compliance: Test and rate fan-coil units in accordance with ARI Standard 440 "Room Fan-Coil Air Conditioners".

5. UL Compliance: Construct and install fan-coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units".
6. UL Compliance: Provide electrical components for terminal units, which have been listed and labeled by UL.
7. ARI Compliance Test and rate unit ventilators in accordance with ARI Standard 330 "Unit Ventilators".
8. AGA Compliance: All gas fired heating equipment shall be AGA Design Certified.
9. Electric Heating Equipment: All equipment with a heating coil capacity exceeding a 48 amp rating shall have the heating elements subdivided and protected by an overcurrent protection device rated at not more than 60 amps. Equipment not exceeding 48 amps shall also have overcurrent protection. Overcurrent protection devices shall be factory wired and installed in accordance with the National Electric Code. All equipment shall be factory assembled and wired in accordance with the National Fire Protection Association and shall be listed by Underwriters' Laboratories.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, for terminal units showing dimensions, capacities, ratings, performance characteristics, gauges and finishes of materials, and installation-startup instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating terminal unit dimensions, weight loading, required clearances, construction details, field connection details and methods of assembly of components.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 15.
- E. Samples: Submit 3 samples of each type of cabinet finish furnished.
- F. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, control, accessories, "trouble-shooting" maintenance guide, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 15.

1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.
- B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Baseboard Radiation
 - a. Slant/Fin Corp.
 - b. Vulcan
 - c. Sterling Radiator; Div. of Reed National Corp.
 - d. Trane
 - e. Weil-McLain, Marley Co.
2. Finned Tube Radiation
 - a. Dunham-Bush, Inc.
 - b. Slant/Fin Corp.
 - c. Vulcan
 - d. Sterling Radiator; Div. of Reed National Corp.
 - e. Trane
3. Unit Heaters
 - a. Airtherm Mfg. Co.
 - b. Vulcan
 - c. Dunham-Bush, Inc.
 - d. McQuay Inc.
 - e. Modine Mfg. Co.
 - f. Trane
4. Cabinet Unit Heaters
 - a. Airtherm Mfg. Co.
 - b. Dunham-Bush, Inc.
 - c. McQuay Inc.
 - d. Trane
 - e. Vulcan
5. Fan Coil Units
 - a. Airtherm Mfg. Co.
 - b. Corp.
 - c. Dunham-Bush, Inc.
 - d. McQuay Inc.
 - e. Trane
 - f. York; Div. of York International
 - g. International Fan Coil

2.2 BASEBOARD RADIATION:

A. General: Provide (hot water) (steam) (electric) baseboard radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.

- B. Cabinets: Minimum 20-ga cold-rolled steel, one-piece back and top panel, front panel with integral damper. Provide steel brackets inserted in back/top panel, to support element and front panel. Provide standard/custom/prime coat baked enamel finish on topside and front panel only.
- C. Elements: Copper tube and aluminum fins, with slide mechanism between element and support brackets to eliminate expansion and contraction noises.
- D. Accessories: Provide the following accessories:
 - 1. End panels, inside and outside corners, and enclosure extensions.
 - 2. Removable 18" long cover access section in front of valves, balancing cocks, and traps.
 - 3. Factory-mounted dampers.
 - 4. Sill extensions.
 - 5. Mullion channels.
 - 6. Pilaster covers.

2.3 FINNED TUBE RADIATION:

- A. General: Provide (hot water) (steam) finned tube radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.
- B. Cabinets: Minimum 18/16/14 ga. cold-rolled steel, continuous 20-ga. partial height/full height backplate, minimum 16/18/14 ga. front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.
- C. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.
- D. Finish: Unfinished zinc coated steel/flat black heat resisting paint backplate, standard factory color selected baked enamel finish/[custom color as selected by Architect in baked enamel finish on front, sides, top and accessories.
- E. Accessories:
 - 1. End panels, inside and outside corners, and enclosure extensions.
 - 2. Removable 18" long hinged cover access section in front of valves, balancing cocks, and traps.
 - 3. Factory-mounted dampers.
 - 4. Sill extensions.
 - 5. Mullion channels.
 - 6. Pilaster covers.

2.4 UNIT HEATERS:

- A. General: Provide unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.
- B. Horizontal Unit Heaters:
 - 1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Provide motor- mounted panel, minimum of 18-ga steel. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for 4-way air diffusion.

2. Fans: Construct of aluminum, and factory-balance. Provide fan inlet orifice, smooth, and drawn into casing back panel.
 - C. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in hot water applications.
 - D. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.
- 2.5 CABINET UNIT HEATERS:
- A. General: Provide hot water cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
 - B. Chassis: Galvanized steel wrap-around structural frame with edges flanged.
 - C. Insulation: Faced, heavy density glass fiber.
 - D. Cabinet: 16-ga removable front panel, 18-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish/Custom color as selected by Architect in baked enamel finish.
 - E. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.
 - F. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass- reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
 - G. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit.
 - H. Filters: Provide 1" thick throwaway type filters in fiberboard frames.
 - I. Accessories: Provide the following accessories as indicated and/or scheduled:
 - J. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
 1. Recessing Flanges: Provide 18-ga steel flanges for recessing cabinet heaters into wall or ceiling.
 2. Sub-bases: Provide 18-ga steel sub-base for vertical units, height as indicated.
 3. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.
- 2.6 FAN-COIL UNITS:
- A. General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coils, fanboard, drain pan assembly, fans, housing, motor, filter, and insulation.
 - B. Chassis: Construct chassis of galvanized steel with flanged edges.

- C. Insulation: Faced, heavy density glass fiber.
- D. Cabinet: Construct of 18-ga steel removable panels, 16-ga front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish./ Custom color as selected by Architect in baked enamel finish.
- E. Coils: Construct of 1/2" seamless copper tubes mechanically bonded to configured aluminum fins. Design for 250 psi working pressure, and leak tested at 350 psi under water.
- F. Auxiliary Heating Coils: Construct of 1/2" seamless copper tubes mechanically bonded to configured aluminum fins. Design for 250 psi working pressure.
- G. Drain Pans: Construct of galvanized steel. Insulate with polystyrene or polyurethane insulation. Provide drain connection.
- H. Fans: Provide centrifugal forward curved double width wheels of reinforced fiberglass, in galvanized steel fan scrolls.
- I. Motors: Provide motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords.
- J. Filters: Provide 1" thick throwaway type filters in fiberboard frames.
- K. Dampers: Provide 18-ga steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electric operators for 25% open cycle.
- L. Accessories: Provide the following accessories as indicated and/or scheduled:
 - 1. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
 - 2. Discharge Grille Panels: Provide 18-ga galvanized steel, stamped integral grilles, with access doors.
 - 3. Sub-Bases: Provide 18-ga steel sub-base, height as indicated.
 - 4. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.
 - 5. Recessing Flanges: Provide 18-ga steel flanges for recessing fan-coil units into wall or ceiling.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASEBOARD RADIATION:

- A. General: Install baseboard radiation as indicated, and in accordance with manufacturer's installation instructions.

- B. Locate baseboard radiation on outside walls as indicated, run cover continuous wall-to-wall unless otherwise indicated.
 - C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.
 - D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, or temperature control valve.
- 3.3 INSTALLATION OF FINNED TUBE RADIATION:
- A. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.
 - B. Locate finned tube radiation on outside walls as indicated, run cover wall-to-wall unless otherwise indicated.
 - C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.
 - D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.
- 3.4 INSTALLATION OF UNIT HEATERS:
- A. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
 - B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
 - C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
 - D. Support units with rod-type hangers anchored to building substrate.
 - E. Install piping as indicated.
 - F. Protect units with protective covers during balance of construction.
- 3.5 INSTALLATION OF CABINET HEATERS:
- A. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
 - B. Locate cabinet heaters as indicated, coordinate with other trades to assure correct recess size for recessed units.
 - C. Install piping as indicated.
 - D. Protect units with protective covers during balance of construction.
- 3.6 INSTALLATION OF FAN-COIL UNITS:
- A. General: Install fan-coil units as indicated, and in accordance with manufacturer's installation instructions.

- B. Locate fan-coil units as indicated, coordinate with other trades to assure correct recess size for recessed units.
 - C. Provide piping as detailed on the drawings.
 - D. Provide 3/4" condensate drain pipe from unit drain pan connection to nearest adequate floor drain or drain pipe.
 - E. Protect units with protective covers during balance of construction.
- 3.7 ELECTRICAL WIRING:
- A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - B. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- 3.8 ADJUSTING AND CLEANING:
- A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
 - B. Retouch any marred or scratched surfaces of factory- finished cabinets, using finish materials furnished by manufacturer.
 - C. Install new filter units for terminals requiring same.
- 3.9 START-UP:
- A. Start-up, test, and adjust terminal units in accordance with manufacturer's published start-up instructions. Adjust for proper airflow where applicable.

END OF SECTION 15830

SECTION 15851 - AIR HANDLING FANS

PART 1 - GENERAL:

1.1 DESCRIPTION OF WORK:

- A. Extent of air handling equipment work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Refer to other Division 15 sections for vibration control; control system; sequence of operation; testing, adjusting and balancing.
- C. Refer to Division 16/1 section for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connections at air handling units.
- D. Refer to Section 15040 Paragraph 2.6 for requirements of sheaves and belts for critical areas.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air handling equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Codes and Standards:
 - 1. Fans Performance Ratings: Establish flow rate, pressure, power air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.
 - 2. UL Compliance: Provide air handling equipment which are listed by UL and have UL label affixed.
 - 3. UL Compliance: Provide air handling equipment which are designed, manufactured, and tested in accordance with UL 805 "Power Ventilators".
 - 4. NEMA Compliance: Provide motors and electrical accessories complying with NEMA standards.
 - 5. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings from laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating."
 - 6. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be defined in OSHA Regulation 1910.7.
 - 7. Electrical Component Standards: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical data for air handling equipment including specifications, capacity ratings, dimensions, weights, materials, operating & service/access clearance accessories furnished, and installation instructions.

- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.
 - C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air-handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are manufacturer-installed and portions to be field-installed.
 - D. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 15.
 - E. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals in accordance with requirements of Division 15.
- 1.4 DELIVERY, STORAGE, AND HANDLING:
- A. Lift and support units with the manufacturer's designated lifting or supporting points.
 - B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
 - C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.
- 1.5 SEQUENCING AND SCHEDULING:
- A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.
 - B. Coordinate the installation of roof curbs, equipment supports, and roof penetrations.
 - C. Coordinate the size and location of structural steel support members.
- 1.6 EXTRA MATERIALS:
- A. Furnish one additional complete set of belts for each belt-driven fan.

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS:
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Inline Centrifugal Fans:
 - a. Acme Engineering and Manufacturing Corp.
 - b. Buffalo
 - c. Loren Cook Co.
 - d. Penn Ventilator Co.
 - e. Jenn Industries Inc.
 - f. New York Blower Co.
 - g. Greenheck

- h. Carnes
 - 2. Centrifugal Roof Ventilators:
 - a. Acme Engineering and Manufacturing Corp.
 - b. Aerovent, Inc.
 - c. Briedert Co., C.G.
 - d. Carnes Company, Inc.
 - e. Loren Cook Co.
 - f. Jenn Industries, Inc.
 - g. Penn Ventilator Co., Inc.
 - h. Greenheck
 - 3. Upblast Propeller Roof Exhaust Fans:
 - a. Loren Cook Co.
 - b. Essick Air Products, Breidert.
 - c. Greenheck
 - d. ILG Industries, Inc.
 - e. Carnes
 - 4. Prefabricated Roof Curbs
 - a. Custon Curb, Inc.
 - b. Pate Co.
 - c. S & L Manufacturing Co.
 - d. ThyCurb Div.; Thybar Corp.
- 2.2 FANS, GENERAL:
- A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.
 - B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
 - 1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.
 - C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
 - 1. Service Factor: 1.4.
 - D. Belts: Oil-resistant, nonsparking, and nonstatic.
 - E. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions. Provide energy efficient motor.
 - 1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

NOTE: Light duty/8 hours/day operation, 20,000 to 60,000 medium duty/8 to 16 hours/day operation, 60,000 to 100,000 and heavy duty/24 hours/day operation 100,000 to 200,000.

- F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" AFBMA L10 of [] calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.
- G. Factory Finish: The following finishes are required:
 - 1. Sheet Metal Parts: Prime coating prior to final assembly.
 - 2. Exterior Surfaces: Baked-enamel finish coat after assembly.
- H. Vibration: Provide vibration isolators as specified in Section 15241 and as indicated.

2.3 INLINE CENTRIFUGAL FANS:

- A. General Description: Inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.
- B. Housing: Split, spun-aluminum housing, with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.
- D. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Wheel: Aluminum, airfoil blades welded to aluminum hub.
- F. Bearings: Grease lubricated ball or roller anti-friction type with extended lubrication lines to outside fan housing.
- G. Accessories: The following accessories are required as indicated:
 - 1. Volume Control Damper: Manual operated with quadrant lock, located in fan outlet.
 - 2. Companion Flanges: For inlet and outlet duct connections.
 - 3. Fan Guards: Expanded metal in removable frame.
 - 4. Speed Control: Variable speed switch with on-off control and speed control for 100 to 50 percent of fan air delivery.

2.4 CENTRIFUGAL ROOF VENTILATORS:

- A. General Description: Belt-driven or direct-drive as indicated, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

- B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
- C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
- D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
 - 1. Pulleys: Cast-iron, adjustable-pitch.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
 - 4. Fan and motor isolated from exhaust air stream.
- E. Accessories: The following items are required as indicated:
 - 1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable 1/2-inch mesh, 16-gauge, aluminum or brass wire.
 - 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.

| OR

Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.

- a. Blades: Die-formed sheet aluminum.
- b. Frame: Extruded aluminum, with waterproof, felt blade seals.
- c. Linkage: Nonferrous metals, connecting blades to counter weight or operator.
- d. Operators: Manufacturer's standard electric motor.

| OR

Operators: Manufacturer's standard pneumatic motor.

- 4. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch-thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
 - a. Overall Height: 12 inches.

2.5 AXIAL ROOF VENTILATORS:

- A. General Description: Belt-driven or direct-drive as indicated, axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; and square, one-piece, hinged, aluminum base.
- C. Fan Wheel: Aluminum hub and blades.
- D. Fan Wheel: Steel hub and blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:
 - 1. Pulleys: Cast-iron, adjustable-pitch.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.
- F. Accessories: The following items are required as indicated:
 - 1. Disconnect Switch: Nonfusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable, 1/2-inch mesh, 16-gauge aluminum or brass wire.
 - 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.

| OR

Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.

- a. Blades: Die-formed sheet aluminum.
- b. Frame: Extruded aluminum, with waterproof, felt blade bumpers.
- c. Linkage: Nonferrous metals.
- d. Operators: Manufacturer's standard electric motor.

| OR

Operators: Manufacturer's standard pneumatic motor.

- 4. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch-thick, rigid fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof deck; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
 - a. Overall Height: 12 inches.

2.6 UPBLAST PROPELLER ROOF EXHAUST FANS:

- A. General Description: Belt-driven or direct-drive as indicated, propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- B. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel, containing galvanized steel butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

OR

Wind Band, Fan Housing, and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

- 1. Dampers Rods: Steel with bronze bearings.

OR

Dampers Rods: Steel with nylon bearings.

- C. Fan Wheel: Dynamically and statically balanced, replaceable, cast- aluminum blades fastened to cast-aluminum hub. Factory-set pitch angle of blades.

OR

Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.

- D. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow- block-type ball bearings.
- E. Motors and Fan Wheel Pulleys: Adjustable pitch. Select pulley so that pitch adjustment is at the middle of the adjustment range at design conditions.
- F. Motors Mounts: Outside of the fan cabinet with adjustable base for belt tensioning, drive assembly and belts enclosure, and weatherproof housing of same material as fan housing.
- G. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch-thick, rigid fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof deck; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
 - 1. Overall Height: 12 inches.

2.7 PREFABRICATED ROOF CURBS:

- A. Furnish and install roof curbs as scheduled for duct openings through the roof and for exhaust fan support. The curbs shall be galvanized steel self-flashing type/with integral cant, for flashing in the field. If the curbs are to have sound attenuation qualities, they shall be not less than those catalogued for the equipment specified.

PART 3 - EXECUTION

3.1 EXAMINATION:

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fans.
- B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL:

- A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units using vibration control devices as indicated. Vibration control devices are specified in Division 15 Section "Vibration Controls."

- 1. Support floor-mounted units on concrete equipment bases using neoprene pads. Secure units to anchor bolts installed in concrete equipment base.

| OR

Support floor-mounted units on concrete equipment bases using housed spring isolators. Secure units to anchor bolts installed in concrete equipment base.

- 2. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
 - a. Installation of roof curbs is specified in Division 7.
- 3. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

3.3 CONNECTIONS:

- A. Duct installations and connections are specified in other Division 15 sections. Make final duct connections on inlet and outlet duct connections with flexible connections.

- B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

- 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division -16 sections. Ensure that rotation is in direction indicated and intended for proper performance. Do not proceed with centrifugal fan start-up until wiring installation is acceptable to centrifugal fan Installer.
- 2. Temperature control wiring and interlock wiring are specified in Division 15.
- 3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

3.4 FIELD QUALITY CONTROL:

- A. Upon completion of installation of air handling equipment, and after motor has been energized with normal power source, test equipment to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.
- B. Manufacturer's Field Inspection: Arrange and pay for a factory- authorized service representative to perform the following:
 - 1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.
 - 2. Prepare a written report on findings and recommended corrective actions.

3.5 ADJUSTING, CLEANING, AND PROTECTING:

- A. Startup, test and adjust air handling equipment in presence of manufacturer's authorized representative.
- B. Adjust damper linkages for proper damper operation.
- C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

3.6 SPARE PARTS:

- A. General: Furnish to Owner with receipt one spare set of belts for each belt driven air handling equipment.

3.7 COMMISSIONING:

- A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:
 - 1. Remove shipping blocking and bracing.
 - 2. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
 - 3. Perform cleaning and adjusting specified in this Section.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
 - 6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.
 - 7. Disable automatic temperature control operators.
- B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
 2. Replace fan and motor pulleys as required to achieve design conditions.
 3. Measure and record motor electrical values for voltage and amperage.
- C. Shut unit down and reconnect automatic temperature control operators.
- D. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.
- 3.8 DEMONSTRATION:
- A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:
1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.
 2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 1 Section "Project Closeout" and Division 15 Section "Basic Mechanical Requirements."
- B. Schedule training with at least 7 days' advance notice.

END OF SECTION 15851

SECTION 15855 – SEMI-CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of air handling unit work is indicated on drawings and schedules, and by requirements of this section.
- B. Types of packaged air handling units specified in this section include the following:
 - 1. Semi-custom indoor air handling units.
- C. Refer to other Division 15 sections for vibration control units used in conjunction with air handling units; field-applied insulation to air handling units; piping required in conjunction with air handling units; not work of this section.
- D. Electrical Work: Refer to Division-15 section "Electrical Provisions of Mechanical Work" for requirements.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
 - a. Control wiring specified as work of Division-15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of semi-custom packaged air handling units with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.
 - 2. ARI Compliance: Test and rate air handling units in accordance with ARI 260, 410, 430 and 1060D display certification symbol on units of certified models.
 - 3. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
 - 4. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".
 - 5. UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA Standards.

6. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, gauges and finishes of materials, and installation instructions.
- B. Shop Drawings: Submit assembly-type shop drawings showing section by section unit dimensions, weight loadings, required clearances, construction details, and field connection details.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 15.
- E. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals; in accordance with requirements of Division 15.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver air handling units with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.
- B. Handle air handling units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; replace and return damaged components to air handling unit manufacturer.
- C. Store air handling units in clean dry place and protect from weather and construction traffic.
- D. Comply with Manufacturer's rigging and installation instructions for unloading air handling units, and moving them to final location.
- E. Air handling units shall be broken down and shipped in components as field conditions require. A factory authorized representative shall inspect the final installation to certify that the unit has been reassembled per factory recommendations and specifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide air handling units of one of the following:
 1. Trane
 2. York

3. McQuay
4. Lennox

2.2 SEMI-CUSTOM INDOOR AIR HANDLING UNITS:

- A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current ARI 410 standard.
- B. Certify air-handling units in accordance with ARI 430.
- C. Provide one set of extra filters and one set of belts for each air handler.
- D. The equipment manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up. This warranty shall state that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.
- E. Unit Casing:
 1. Unit shall be constructed of a complete structural frame with removable panels. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished to meet ASTM B 117 250-hour salt-spray test. The removal of side panels shall not affect the structural integrity of the unit. All removable panels shall be gasketed to minimize air leakage. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.
 2. Access panel and/or access doors shall be available on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection and maintenance. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.
 3. Access doors shall be double wall construction to prevent damage to insulation during routing maintenance.
 4. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of all interior surfaces.
 5. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.
 6. All joints between exterior panels and structural frames, as well as joints between module frames, shall be properly sealed and gasketed to provide an air seal.
 7. Insulation – high density, matte-faced-interior surface of unit casing shall be acoustically and thermally lined. Insulation shall be installed with adhesive. Insulation shall have a minimum R-value of 4 and shall be UL listed. The installation shall comply with NFPA 90A and B requirements. If edges of fiberglass insulation are exposed, the manufacturer shall be responsible for sealing exposed edges with mastic sealer to prevent erosion into the air-stream.
 8. To facilitate inspection of internal components, provide sealed tempered glass view windows in doors accessing moving parts.

9. Provide marine lights in all sections. Marine light shall be UL listed for wet locations. Light shall be complete with bulb and junction box.
10. Provide concrete 4" housekeeping pad under casing. Isolate unit form pad with [rubber gasket] [3/4" rubber waffle pad] [full perimeter spring rail].

F. Fans:

1. Provide [DWDI FC] [DWDI BI] [DWDI BIAF] [plug type] supply fans. Provide [DWDI FC] [DWDI BI] [DWDI BIAF] [plug type] return fans. Fan shafts shall be solid, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment as speeds between 25% and 100% of design RPM. If fans are not factory-tested responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.
2. When plug fans are used, provide door switches for fan shut-down when access door is opened.
3. Provide grease lubricated ball bearings selected for L-50 400,000 hour average life per ANSI/AFBMA 9. Greasable bearings shall have lubrication lines extended to the drive side of the unit. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. Extend both grease lubrication lines to drive side of unit and rigidly attach to drive side bearing support with zerk fittings. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.
4. Fans shall be mounted on [inertia base] isolation bases. Internally mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Flexible canvas ducts shall be installed between fan and unit casing to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A and UL 181 requirements.
5. Fan modules shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components.
6. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.
7. Motors and Drives:
 - a. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change.
 - b. V-belt drives shall be [constant] [fixed] pitch rated at 1.2 times the motor nameplate.

G. Coils:

1. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drainpan under the coil.
 2. Coils shall be manufactured with plate fins to minimize water carryover and maximized airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across coils as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
 3. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
 4. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated in order to minimize the chance for water carryover.
 5. On stacked cooling coils, intermediate drain pans shall be installed between the coils. Intermediate drain pans shall have drop tubes to guide condensate to the main drain pan, thus preventing flooding of lower coils that would result in moisture carryover.
 6. Hydronic Coils:
 - a. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit air-flow.
 - b. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
 - c. Headers shall be constructed of round copper pipe or cast iron.
 - d. Tubes shall be ½ inch O.D. minimum 0.016 inch thick copper. Fins shall be aluminum.
- H. Base-Level Drain Pans:
1. Insulation shall be encased between exterior and interior walls. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section. Cooling coil drain pans shall be sloped in 2 planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's requirements. See section 2.05, paragraph E for specifications on intermediate drain pans between cooling coils.
 2. Units with heating coils shall have a drain pan under complete heating coil section sloped in 2 planed and pitched toward drain connections to ensure proper drainage during cleaning and to capture water in the event of a coil failure.
 3. All drain pan connections supplied by unit manufacturer including, piping and piping connections extending from stainless steel drain pans shall be constructed of stainless steel. The contractor is responsible to ensure the unit is installed level, trapped in

accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

4. Flat drain pans shall be acceptable in sections that may have incidental, but not continuous contact with moisture. Flat drainpans shall be accessible for cleaning.

I. Filters:

1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter sections shall have filter guides and full height, double-wall, hinged doors for filter removal. Filter sections shall flange to other unit components. Provide filter blockoffs as required to prevent air bypass around filters.
2. Provide 2 inch 30% flat filter sections with throwaway filters. Filters shall be removable from one side(s) of filter sections.

J. Dampers:

1. All dampers, with the exception of external bypass and multi-zones (if scheduled), shall be internally mounted. Dampers shall be premium ultra low leak and located as scheduled. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge and 9 CFM/square foot at 4 inch water gauge. All leakage testing and pressure ratings shall be based on AMCA publication 500. Manufacturer shall submit brand and model of damper(s) being furnished.
2. Provide a factory-mounted ASHRAE standard 62 airflow monitoring and control station in the outdoor air opening of the mixing box. The monitor shall track a variable outside air quantity for ventilation demand flow control and ventilation flow documentation. The airflow monitoring station shall be factory-mounted, factory-calibrated and installed per the airflow monitor manufacturer's recommendations.
 - a. The air handling unit mixing box shall also include a modulating outside air damper mounted in series with the air flow monitor.
 - b. All linkages, crank arms, jack shafts and mounting hardware shall be provided.
 - c. The airflow monitoring station shall be calibrated to measure a variable airflow from 15% of nominal airhandler CFM up to 100% of design airflow, maintaining an accuracy of plus or minus five (5%) percent of actual CFM, for air measuring between -40F and up to +158F. Monitoring station shall compensate for outside air temperature fluctuations that affect mass flow rate of air.
 - d. Manufacturer shall submit test data to demonstrate compliance.
 - e. The airflow monitoring station shall provide a proportional output velocity signal (2-10 vdc). The velocity sensor shall have an automatic zeroing function and shall be programmed to recalibrate the device's transducer a minimum of once per day to ensure continuous accuracy of airflow measurements. The monitor manufacturer shall provide to the Building Automation System (BAS) contractor a certified conversion table for the signal provided.

K. Access Sections:

1. Access for inspection and cleaning of the unit drain pan, coils and fans sections shall be provided. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be included in the maintenance manual. Access section shall have double wall, hinged, removable access doors on one side of section. Construct doors per section 2.03 paragraphs D, E and F.
2. To facilitate inspection of internal components, provide sealed tempered glass view windows in access doors accessing moving parts.
3. Provide marine lights in sections as specified on schedule. Marine light shall be UL listed for wet locations. Light shall be complete with bulb and junction box.

L. General Unit Sections:

1. Air Blender: The blender shall be of the rotary design with radial blades. Blender shall have the proper distances upstream and downstream s recommended by the blender manufacturer. Minimum mixing effectiveness shall be 75 percent when mixing 50 percent outside air and 50 percent return air at 50 F initial inlet temperature differential. Construct blender of .080 aluminum.
2. Moisture Eliminator: Provide moisture eliminator with galvanized fins and drain pan in the casing.
3. Diffuser Section: On units provided with coils or filters immediately downstream of double inlet housed centrifugal fans, provide a factory mounted diffuser section as shown on the drawings to promote equal air distribution.
4. Acoustical Attenuator: Provide factory mounted sound attenuation section(s). Attenuation section(s) shall be made of double wall construction with minimum 20 gauge galvanized perforated steel liner. Acoustical attenuator(s) length shall be sized to meet discharge sound power levels as defined in schedule. Space shall be provided both upstream and downstream of attenuator section(s) as required by attenuator manufacturer to insure smooth transition of airflow into and out of attenuator.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which air handling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF AIR HANDLING UNITS:

- A. General: Install air handling units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.
- B. Coordination: Coordinate with other work, including ductwork, floor construction, roof decking, and piping, as necessary to interface installation of air handling units with other work.
- C. Access: Provide access space around air handling units for service as indicated, but in no case less than that recommended by manufacturer.

- D. Support: Install floor-mounted air handling units on 4" high reinforced concrete pad, a minimum of 4" larger on each side than unit base.
 - E. Support: Install roof-mounted air handling units on structural steel mechanical stand. Anchor unit to stand with removable fasteners.
 - 1. Construct mechanical equipment stand as indicated, and in accordance with NRCA Handbook of Accepted Roofing Knowledge, Detail "N".
 - 2. Mechanical equipment stand is specified in Division 5; not work of this section.
 - F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
 - G. Piping Connections: Refer to Division-15 HVAC sections. Provide piping, valves, accessories, gauges, supports, and as indicated.
 - 1. Provide flexible connectors shutoff valves, balancing valves, unions, thermometers (supply and return), P & T types (supply & return) and other accessories on all piping connections.
 - H. Duct Connections: Refer to Division-15 Air Distribution sections. Provide ductwork, accessories as indicated.
 - I. Grounding: Provide positive equipment ground for air handling unit components.
- 3.3 FIELD QUALITY CONTROL:
- A. Testing: Upon completion of installation of air handling units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.
- 3.4 EXTRA STOCK:
- A. Provide one complete extra set of filters for each air handling unit. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.
 - B. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.
- 3.5 TRAINING:
- A. Schedule a minimum of 4 hours of training with Owner. The manufacturers representative, and the Division 15 contractor shall be present. The training shall be coordinated by the Division 15 contractor and the Owner in conjunction with the other mechanical equipment on the project.
 - B. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in Division 1 and Section 15010.
2. Schedule training with Owner through the Architect/ Engineer with at least 7 days prior notice.

END OF SECTION 15855

SECTION 15885 - AIR CLEANING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of air cleaning work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of air cleaning equipment specified in this section include the following:
 - 1. Air Filters.
 - 2. Filter Holding Systems.
 - 3. Filter Gauges.
- C. Filter sections of packaged air handling units are work of this section.
- D. Refer to Division 16 sections for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on air filter units. Include disconnects and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and air filter unit control panels.
 - a. Control wiring specified as work of Division 15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air cleaning equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B, and NEC pertaining to installation of air filters and associated electric wiring and equipment.
 - 2. UL Compliance: Comply with UL Standards pertaining to safety and performance of air filter units.
 - 3. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.
 - 4. ARI Compliance: Comply with provisions of ARI Standard 850 pertaining to test and performance of air filter units.

1.3 SUBMITTALS:

- A. Submit product data, shop drawings, and wiring diagrams as specified in Section 15010.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

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

1. Air Filters and Housings:
 - a. Continental Filter Corp.
 - b. Farr Corp.
 - c. Flanders Filters, Inc.
 - d. Viledon
 - e. Tri-Dim Corp.
 - f. Eco Air
 - g. American Air Filter
 - h. Charcoal Services, Co.

2.2 AIR FILTERS:

A. Pleated Media Filters: Provide factory-fabricated, flat panel, dry, pleated, surface filters with holding frames; where shown, in sizes indicated with UL Class 2, self-extinguishing, high loft, non-woven, cotton/synthetic, media material formed into 2" deep radial pleats, supported by an expanded metal or wire mesh, in a die cut moisture resistant fiber board frame. Provide filters with rated face velocity of 500 fpm, initial resistance of 0.30" w.g. with average 25-30% efficiency, base on ASHRAE Test Standard 52 with 90-95% dustspot efficiency, final rated resistance of 1.00" w.g., and average arrestance of 94-96%.

2.3 FILTER HOLDING SYSTEMS:

A. Front and Rear Access Filter Frames: Provide filter bank framing system, constructed of 16 gauge galvanized steel. Design system for either [upstream (front)] or [downstream (rear)] filter servicing. Cut to size and pre-punch members for easy assembly into modules of size and capacity as scheduled or noted on drawings. Provide permanently gasketed framing members to prevent bypass of unfiltered air. If vertical support members are required to prevent deflection of horizontal members, install so as not to interfere with either installation or operation of filters. Incorporate common gasketed prefilters and final filters, filter frame with four filter retainer clips for each filter frame, removable from front/back. Provide factory-installed positive sealing device for each row of filters, to insure seal between gasketed filter elements. Provide hardware necessary for field assembly.

B. Side Servicing Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated. Construct of 16-ga galvanized steel. Provide integral pre-filter tracks to accommodate 2" throw- away or cleanable filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass. Arrange so filter cartridges can be loaded from either access door.

1. Leak-test housing by pressurizing to 3" w.g. and soap- bubble test housing joints, door seals, and filter sealing edges. Provide crank-operated spring-loaded filter-sealing mechanism with limit stop, so geared that total pressure of 600 lbs. will be exerted on each filter. Design clamping frame to provide continuous knife-edge seal for all four edges of each individual filter.

2.4 FILTER GAUGES:

- A. Provide diaphragm-type filter gauge for each filter bank, with dial and pointer, graduated to read from 0 to 2" [] w.g.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which air filters and filter housings will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

- A. General: Comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.
- B. Install air filters and holding frame devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes.
- C. Locate each filter unit accurately in position indicated, in relation to other work. Position unit with sufficient clearance for normal service and maintenance.
- D. Anchor filter holding frames securely to substrate. Provide intermediate steel support bars between every other column of frames on filters high, or as recommended by manufacturer.
- E. Coordinate with other work including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.
- F. Install filters in proper position to prevent passage of unfiltered air. Seal between each filter frame and filter frame and plenum housing airtight.
- G. Install air filter gauge pressure tips upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gauges if any, for proper readings.

3.3 FIELD QUALITY CONTROL:

- A. Operate installed air filters to demonstrate compliance with requirements. Test for air leakage of unfiltered air while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with retesting.

3.4 EXTRA STOCK:

- A. Provide one complete extra set of filters for each air handling system. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

END OF SECTION 15885

SECTION 15891 - METAL DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

DUCT SERVICE	TYPE/CONSTRUCTION
Supply air between fan and terminal boxes (medium and high).	Galvanized steel, spiral, round or oval /rectangular.
Rectangular supply air from discharge of terminal box/fan to air devices (low pressure).	Galvanized sheet metal /spiral round and oval or rectangular (lined as noted on drawings.)
Return air ductwork.	Galvanized steel (lined where noted on drawings); factory or shop fabricated.).
General building exhaust.	Galvanized sheet metal (lined as noted on drawings); factory or shop fabricated.).
Transfer ducts.	Internally lined galvanized sheet metal as described above for low pressure supply; factory or shop fabricated.
Sound elbows for R.A. grilles	Galvanized sheet metal (internally lined). OR Fibrous glass ductboard.
Outdoor air intake ductwork.	Galvanized sheet metal, rectangular, factory or shop fabricated.

- B. Exterior insulation of metal ductwork is specified in other Division-15 sections, and is included as work of this section.
- C. Refer to other Division-15 sections for ductwork accessories.
- D. Refer to other Division-15 sections for fans and air handling units.
- E. Refer to other Division-15 sections for testing, adjusting, and balancing of metal ductwork systems.

1.2 DEFINITIONS:

- A. Low Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to 2" or less, positive or negative pressure class.

- B. Medium or High Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to greater than 2" positive or negative pressure class.

1.3 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.
- C. References to SMACNA, ASHRAE and NFPA are minimum requirements, the Contractor shall fabricate, construct, install, seal and leak test all ductwork as described in this specification and as shown on the drawings, in addition to these minimum standard references.
- D. Codes and Standards:
 - 1. SMACNA Standards: Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.
 - 2. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" and NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems".
- E. SMACNA Industrial Construction Standards.
- F. Field Reference Manual: Have available for reference at project field office, copy of SMACNA "HVAC Duct Construction Standards, Metal and Flexible", and SMACNA "HVAC Air Duct Leakage Test Manual".

1.4 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data and installation instructions for ductwork materials and products. Provide product data for manufactured joining systems. Include sound attenuation by octave band for sound rated flexible duct.
- B. Shop Drawings: Submit 1/4" scaled fabrication and layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.
- C. Record Drawings: At project closeout, submit record drawings of installed systems, in accordance with requirements of Divisions 1 and 15.
- D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Divisions 1 and 15.

1.5 DELIVERY, STORAGE, AND HANDLING:

- A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.
- B. Storage: Store ductwork inside elevated from floor on pallets. At no time shall the inside surfaces be exposed, or stored with open ends and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Duct Liner:
 - a. CertainTeed Corp.
 - b. Manville Products Corp. (Schuller)
 - c. Owens-Corning Fiberglas Corp.
 - d. Pittsburgh Corning Corp.
 - 2. Flexible Ducts:
 - a. Flexmaster
 - b. Thermaflex
 - 3. Duct Take Off Fittings
 - a. Hercules Industries
 - b. Flexmaster
 - c. Thermaflex
 - d. Ominair
 - 4. Round and flat oval Ductwork (low, medium, and high pressure):
 - a. Semco Mfg., Inc.
 - b. United Sheet Metal Div., United McGill Corp.
 - c. Sheet Metal Products Co.
 - d. Spiral Pipe of Texas, Inc.
 - e. Hercules Industries

2.2 DUCTWORK MATERIALS:

- A. Exposed Ductwork Materials: Where ductwork is exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains, dents, discolorations, and other imperfections, including those which would impair painting.
- B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality; with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations. Provide flat seam construction where standing seams are a hazard to the Owner's operation personnel.

2.3 MISCELLANEOUS DUCTWORK MATERIALS:

- A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 deg. change of direction per section. Unless specifically detailed otherwise, use 45 deg. laterals and 45 deg. elbows for branch takeoff connections. Where 90 deg. branches are indicated, provide conical type tees.
- C. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of thickness indicated.
 - 1. Unless otherwise noted, provide 1" thick, 1-1/2 lb density, fiberglass duct liner meeting ASTM C1071 Type I, NFPA 90A and 90B and TIMA (AHC-101) with minimum NRC (noise reduction coefficient) of 0.70 as tested per STM C 423 using an "A" mounting with minimum "K" factor of 0.25. Lining shall be U.L. approved, made from flame attenuated glass fiber bonded with a thermosetting resin with acrylic smooth surface treatment and factory applied edge coating. Materials shall conform to revised NFPA No. 90A Standards, with a maximum flame spread of 25 and maximum smoke development of 50.
 - 2. Provide rigid plenum liner board where indicated. Rigid liner shall be [1", 1-1/2", 2"] thick, 3 pounds per cubic foot, glass fiber bonded with thermosetting resin, with an acrylic coating, conforming to NFPA 90 and ASTM C1071.
 - a. Schuller/Manville Permacote Linacoustic R-300.
- D. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".
- E. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.
- F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/ installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork.
- G. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
 - 1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
 - 2. For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.
- H. Flexible Ducts: Flexible air ducts shall be listed under UL-181 standards as Class I Air Duct Material and shall comply with NFPA Standards 90A and 90B. Minimum operating pressure rating shall be 6" W.C. through a temperature range of -20° to 150°F; minimum working velocity rating shall be 4000 f.p.m. Contractor shall assume responsibility for supplying material approved by the authority having jurisdiction.

1. All insulated flexible ducts shall be constructed of a metalized ripstop reinforced laminate inner core, 1" thick, 3/4 lb. density fiberglass insulation with "C" factor of 0.23 or less and an outer jacket made exclusively of fire retardant reinforced aluminized material.
 - a. Flexmaster Type 5M.
2. All/Where shown on drawings flexible duct shall be rated for sound attenuation. Inner core shall be black CPE supported by a galvanized steel helix, with 1" C=.23 or less insulation and metalized reinforced outer jacket. Sound attenuation shall be as scheduled below:

INSERTION LOSS, PER 10' SECTION, ZERO FLOW						
Octave Band	125	250	500	1000	2000	4000
IL (dB) 8" dia.	13	31	36	35	38	21

- a. Flexmaster Type 8M
3. Non-insulated flexible ducts shall be constructed from dead soft aluminum sheet, spiral corrugated, or aluminum construction over a steel spring helix.
 - I. Duct Take Off Fittings to Individual Air Inlets & Outlets: Provide conical spin-in fittings at flexible or round sheet metal duct takeoffs. Where specifically shown on drawings, where the duct dimension does not allow for a conical spin-in, or at Contractor's option, provide 45° inlet rectangular to round duct take off fittings, with factory applied gasket. Fittings shall include butterfly type manual volume damper with regulator, and dual locking device. Dual locking device shall consist of two shaft mounted wing nuts, one on each side of the damper. Wing nuts shall tighten on shafts to lock butterfly in place. Shafts shall be solid metal, rolled metal shafts are not acceptable.

Hercules Model 9000 (conical)
Hercules Model 6000 (straight-spin)

- J. See detail on drawings for installation requirement.
 - K. All fasteners and hardware for stainless steel ductwork shall be made of stainless steel.
- 2.4 FABRICATION:
- A. Fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match- mark sections for reassembly and coordinated installation.
 - B. Fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards". Minimum 26 GA where ducts are within corridors.
 - C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

- D. If manufacturer flange joining systems are used as part of the reinforcing, the EI rating and rigidity class shall be equivalent to the reinforcing requirements of the standard. Submit manufacturer's product data.
- E. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.
- F. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to 1.5 times the associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 deg. for contracting tapers and 20 deg. for expanding tapers. Divided flow fittings shall be 45° inlet branches, stationary splitters and elbows, or as shown on drawings.
- G. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-15 section "Ductwork Accessories" for accessory requirements.
- H. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners. Provide sheet metal nosing on all leading edges preceded by unlined duct, at duct openings, and at fan or terminal unit connections.

2.5 LOW PRESSURE ROUND DUCTWORK:

- A. Material: Galvanized sheet steel complying with ASTM A 527, lockforming quality, with ASTM A 525, G90 zinc coating, mill phosphatized. Spiral lockseam construction. Individual runouts to diffusers may be longitudinal seam.
- B. Gauge: 28-gauge minimum for round and oval ducts and fittings, 4" through 24" diameter. Minimum 26 gauge where ducts are within a corridor.
- C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Spot welded and bonded construction.
- D. Divided Flow Fittings: 90 deg. tees, constructed with branch spot welded and bonded to duct fitting body, or saddle tap fitting, with minimum 2" flange shaped to fit main duct.

2.6 MEDIUM AND HIGH PRESSURE ROUND AND FLAT OVAL DUCTWORK:

- A. General: Provide factory-fabricated duct and fittings.
- B. Duct gauges given below are minimum values; in no case shall the duct gauge be less than recommended by SMACNA for the operation pressures of the systems shown on the drawings, (both positive and negative pressures), including proper re-enforcement.
- C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Fully welded construction.
- D. Divided Flow Fittings: Full body fittings with solid welded construction or solid welded saddle tap fittings with a minimum 2" flange shaped to fit the main duct. Provide conical laterals, conical tees, 45° inlet tees, wye fittings, or as shown on drawings. Straight tap tees shall not be used.

- E. Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.

Diameter	Minimum Gauge	Method of Manufacture
3" to 14"	26	Spiral Lockseam
15" to 26"	24	Spiral Lockseam
27" to 36"	22	Spiral Lockseam
37" to 50"	20	Spiral Lockseam
51" to 60"	18	Spiral Lockseam
Over 60"	16	Longitudinal Seam
	18	Spiral Lockseam

1. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct. Provide internal stiffener rings and external reinforcement as required to meet operating static pressures scheduled on drawings.
2. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams.

Diameter	Minimum Gauge
3" to 14"	24
15" to 26"	22
28" to 50"	20
52" to 60"	18
Over 62"	16

- F. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

Maximum Width	Minimum Gauge
Under 25"	24
25" to 48"	22
49" to 70"	20
Over 70"	18 (or 16 GA. Longitudinal welded seam)

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

Maximum Width	Minimum Gauge
Under 37"	20
37" to 59"	18
Over 59"	16

- G. Internally Insulated Duct and Fittings: Construct with outer pressure shell, 1" thick insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 12"	26 ga.	26 ga.
13" to 24"	24 ga.	26 ga.
25" to 34"	22 ga.	26 ga.
35" to 48"	20 ga.	26 ga.
49" to 62"	18 ga.	26 ga.
Over 62"	18 ga.	22 ga.

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 34"	20 ga.	24 ga.
36" to 48"	20 ga.	22 ga.
50" to 58"	18 ga.	22 ga.
Over 58"	16 ga.	22 ga.

2. Inner Liner: Perforate with 3/32" holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL DUCTWORK:

A. Duct Sealing:

1. Seal all low pressure ducts to SMACNA Seal Class "B".
2. Seal all medium and high pressure ducts to SMACNA Seal Class "A".

- B. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.

- C. Construct ductwork to schedule of operating pressures as shown on drawings.

- D. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

- E. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

- F. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

- G. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

- H. Penetrations: Where ducts pass through fire rated walls and do not contain fire or smoke dampers, protect with fire stop material installed in accordance with its listing. Where ducts pass through interior partitions or exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all four sides by at least 1-1/2". Fasten to duct only. Where ducts penetrate non-fire rated, mechanical, electrical or acoustically sensitive walls, provide 1/2" to 3/4" annular space between duct and wall, pack annular space with mineral wood insulation, and caulk both sides with non-hardening acoustical sealant.

- I. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.
 - J. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards and Industrial Construction Standards.
 - K. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.
- 3.3 INSTALLATION OF DUCT TAKE-OFF FITTINGS:
- A. Fully seal all joints.
 - B. Sheet metal screw regulator arm to duct after balance is complete. Mark and date position of regulator arm.
 - C. Insulation over regulator arm is not required.
- 3.4 INSTALLATION OF DUCT LINER:
- A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards.
- 3.5 INSTALLATION OF FLEXIBLE DUCTS:
- A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5' - 0".
 - B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".
- 3.6 FIELD QUALITY CONTROL:
- A. Leakage Tests: Conduct duct leakage test in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than the maximum permissible leakage as specified below.
 - B. General:
 - 1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.
 - 2. Ductwork systems in 3" W.G. pressure class and higher shall be tested in their entirety for leaks. Arbitrary sections of ductwork in 2" W.G. and lower pressure class shall be tested as required by Architect/Engineer.
 - 3. Test Failures: Duct systems shall be repaired if test pressure and leakage requirements are not met or if air noise condition is encountered. Repairs and sealing shall be done with sheet metal, tape, sealant or a combination thereof.

C. Test Equipment:

1. Portable rotary type blower or tank type vacuum cleaner with control damper. Equipment shall have sufficient capacity to properly test reasonably large duct system section.
2. Orifice assembly consisting of straightening vanes and calibrated orifice plate mounted in a straight tube with properly located pressure taps.
3. Two (2) U-tube manometers, one to measure drop across calibrated orifice and one to measure S.P. in duct being tested. Provide low differential pressure Dwyer magnehelic gauges for low leak testing in lieu of U-tube manometers.
4. Provide Dwyer magnehelic gauge with 0-.25" W.C. range for testing 0% leakage ductwork.

D. Testing Pressures and Permissible Leakage:

1. Test pressure shall be equal to the construction class. Negative pressure duct shall be tested at the equivalent positive pressure.
2. Allowable leakage shall be determined from the following equation (or figure 4-1 in the above referenced Standard):

$$F = C_L (P)^{.65}$$

Where: F = Allowable leakage factor CFM/100 Sq. Ft.
C_L = Leakage Class
P = Test pressure inches W.C.

3. Leakage class shall be as follows:
 - a. Seal class A, Round or oval duct, C_L = 3.
 - b. Seal class A, Rectangular duct, C_L = 6.
 - c. Seal class B, Round or oval duct, C_L = 6.
 - d. Seal class B, Rectangular duct, C_L = 12.
 - e. Seal class C, Round or oval duct, C_L = 12.
 - f. Seal class C, Rectangular duct, C_L = 24.
4. Record all tests using the procedure and forms in the above referenced standard.
5. All plenums and casings shall be tested by pressuring to the pressure class indicated and visually observing leakage and panel deflection.
 - a. No noticeable leakage shall be allowed.
 - b. Deflection shall be less than 1/8" per foot.

3.7 EQUIPMENT CONNECTIONS:

- A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors where required for service, maintenance and inspection of ductwork accessories. See section 15910.

3.8 ADJUSTING AND CLEANING:

- A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances. Where ductwork is to be painted clean and prepare surface for painting.
- B. Protection:
 - 1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.
 - 2. Cover all stored ducts to protect from moisture, dust or debris.
 - 3. Maintain a cover on all ends of installed ductwork at all times, except when actually connecting additional sections of duct.
- C. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.
 - 1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
 - 2. Ductliner in installed ductwork which has become wet must be completely removed and replaced.
 - 3. Torn ductliner may be repaired by coating with adhesive if damage is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.
- D. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
- E. Balancing: Refer to Division-15 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.9 INSPECTION:

- A. After completion of the ductwork installation, and after the Test and Balancing work, a minimum of 10% of the installed length of the supply duct system shall be inspected by an independent company specializing in such work. Inspection shall be performed using fiber optic video equipment and other appropriate techniques.
 - 1. Sections to be inspected shall be determined by the Engineer.
- B. A report, including a recording on DVD of the video shall be submitted to the engineer. The report shall document the findings of the inspection, listing any areas of concern, including evidence of water, dust, dirt and construction debris.
- C. If, in the opinion of the Engineer and the Inspection company, the supply ductwork is unacceptably contaminated, the supply duct system shall be cleaned. Additional inspections shall be performed, including sections not previously inspected. This process shall be repeated until, in the opinion of the Engineer, the supply duct system is acceptably clean

END OF SECTION 15891

SECTION 15910 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
- C. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers" and U.L. Standard 555S "Motor-Driven Fire/Smoke Dampers."
- D. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.
- E. SMACNA Compliance: All exhaust ducts comply with "Fire Damper and Heat Stop Guide".
- F. All fire dampers, smoke dampers, fire/smoke dampers and radiation dampers shall meet the latest local building code requirements.

1.2 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components. Include details of construction equipment and accessories being provided.
- C. Submittals for all damper types specified in this section shall include a schedule for each damper indicating net free area, actual face velocity and pressure drop (at sea level) based on net free area & the maximum air quantity which will be passing through the damper. Submittals without this information will be rejected.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 15.
- E. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Dampers:
 - a. Greenheck
 - b. AWV
 - c. Air Balance, Inc.
 - d. Anemostat
 - e. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - f. Louvers & Dampers, Inc.
 - g. Penn Ventilator Co.
 - h. Pottoroff
 - i. Ruskin

2. Fire Dampers and Smoke Dampers:
 - a. Greenheck
 - b. Air Balance, Inc.
 - c. Phillips Industries, Inc. Conaire Division
 - d. Ruskin
 - e. Pottoroff

3. Turning Vanes:
 - a. Aero Dyne Co.
 - b. Airsan Corp.
 - c. Barb-Aire
 - d. Duro Dyne Corp.
 - e. Environmental Elements Corp.; Subs. Koppers Co., Inc.
 - f. Hart & Cooley Mfg. Co.

4. Duct Hardware:
 - a. Ventfabrics, Inc.
 - b. Young Regulator Co.
 - c. Duro-Dyne Corp.

5. Duct Access Doors:
 - a. Kess
 - b. Greenheck
 - c. Flexmaster
 - d. Cesco-Advanced Air
 - e. Duro Dyne Corp.
 - f. Ventfabrics, Inc.

6. Flexible Connections:
 - a. Duro Dyne Corp.
 - b. Ventfabrics, Inc.
 - c. General Rubber Corp. (Process & Exhaust Only)

7. Air Blenders:
 - a. Blender Products, Inc.

2.2 MANUAL VOLUME DAMPERS:

- A. Low Pressure Rectangular Dampers (less than 2000 FPM and under 2" W.C. S.P. Differential):
1. For 12" in height or larger, use multiple opposed blade type and close fitted to ducts. The frame and blades shall be constructed of 16 ga. galvanized steel with plated steel shaft mounted with synthetic bearings. Linkage shall be in-jamb fixed type located outside the airstream made of plated steel tie bar and crank plates, with stainless steel pivots. Damper panels shall not exceed 48" wide. Provide jack shafting when duct size required is greater than 48" wide. Provide notched shaft end indicating damper position, locking quadrant to fix damper position and handle. Provide stand off bracket for insulated ducts. For flat oval and round ductwork, provide type C housing.
 2. For ducts less than 12" in height, frame shall be 18 ga. blade galvanized steel, steel axle with synthetic bearings locking quadrant handle and notched shaft end indicating damper position. Provide stand off bracket for insulated ducts.
- B. Low Pressure Round Dampers (less than 1800 FPM and under 1" W.C. S.P. differential):
1. For low pressure spin-in fitting dampers serving individual returns/diffusers, see 15891.
 2. Dampers 4" diameter through 18" diameter shall be 20 ga. galvanized steel frame and blade, utilize multi-blade square dampers with transitions for ducts over 18" diameter.
- Axle shaft shall be plated steel with retainers mounted on synthetic bearings with notched end shaft indicating damper position, locking quadrant and handle. Provide stand off brackets for insulated ducts.
- a. Greenheck M80R-50 or approved equivalent.
- C. Medium/High Pressure Rectangular Dampers (less than 4000 FPM and under 6" W.C. (48" wide or less) S.P. or 8" W.C. S.P. (36" wide or less)):
1. Dampers shall be opposed blade for volume control and parallel blade for isolation/shut-off service.
 2. Frame shall be 16 ga. galvanized steel with welded corners or 1/8" thick 6063-T5 alloy aluminum frame. Blades shall be double skin galvanized steel with single-lock seam, or .081" thick 6060-T5 extruded aluminum, airfoil shape. Blade edge seals shall be vinyl, silicone, or other approved synthetic and metallic compression seals at the jambs. Axles shall be hexagonal or square plated steel mounted on bronze oilite or synthetic (ACETAL) bearings. Linkage shall be in-jamb type located outside the airstream. Maximum damper size shall be 48" wide and 60" high. For isolation or shut-off duty, damper leakage shall not exceed 9.5 CFM/Ft² at 4" W.C. S.P. differential. Provide extended shaft with notched end indicating damper position, locking quadrant and handle. Provide stand off brackets for insulated ducts.
- D. Medium/High Pressure Round and Flat Oval Dampers (less than 3000 FPM and under 4" W.C. S.P. differential):

1. Damper frame construction shall be galvanized steel as follows:

ROUND

Under 6" dia. 12 Gauge
6" to 18" dia..... 14 Gauge

FLAT OVAL

6" to 12" wide 2 x 1/2 x 14 gauge channel
13" to 48" wide 2 x 1/2 x 1/8 channel

2. Damper blades shall be galvanized steel as follows:

ROUND

4" to 18" diameter 12 Gauge

FLAT OVAL

4" to 18" Wide 12 Gauge

3. Axles shall be 1/2" diameter plated steel up to 18" diameter and 18" wide flat oval, and 3/4" diameter plated steel over 18". Stainless sleeve bearings pressed in to the frame.
4. Provide notched end shaft to indicate damper position, locking quadrant and lever handle. Provide stand off bracket for insulated duct.

2.3 COUNTERBALANCED PRESSURE RELIEF DAMPERS:

- A. For velocities less than 3000 FPM and under 2" W.C. S.P. differential provide dampers with parallel blades, counterbalanced and factory-set, field adjustable, to relieve at indicated static pressure. Construct blades of 16 ga. aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4" x 16 ga. channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

- B. For velocities above 3000 FPM and static pressure differential above 2" W.C.:

Provide dampers with parallel blades, counterbalanced and factory-set, field adjustable to start to open at indicated pressure. Construct blades of 16 gauge galvanized steel up to 32" length and 14 gauge over 32" length, 3/4" diameter plated steel axles, full length, relubricable ball bearings, heavy duty carbon steel linkage located out of airstream, 10 gauge galvanized steel frame silicone blade edge seals and silicone jamb seal, full flanges on both sides, mill finish with touch -up on welds and prime coat on black steel.

2.4 FIRE DAMPERS:

- A. Fabricated Fire Dampers: Provide dampers constructed in accordance with SMACNA "Fire Damper and Heat Stop Guide."
- B. Fire Dampers: Provide dynamic rated type B or C fire dampers except as noted on drawings. Construct sleeve of galvanized steel with bonded red acrylic enamel finish, gauge as required by the listing. All fire dampers shall be UL labeled. Provide fusible link rated at 160 to 165

deg. F (71 to 74 deg. C) unless otherwise indicated. See architectural drawings for the separations and listings. Provide horizontal mounted fire damper with positive lock in closed position, and with the following additional features:

- C. Damper Blade Assembly: Curtain Type.
- D. Blade Material: Galvanized steel.
- E. Provide integral sleeve type G fire dampers for sidewall air devices terminating at fire rated walls. Ruskin DIBD20-G or equivalent.

2.5 SMOKE DAMPERS:

- A. Rectangular Motor-Driven Smoke Dampers: Frame constructed of 16-ga. steel, type 304 stainless steel side seals, silicone edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel formed interlocking blades, with factory mounted actuator motor, motor mounting bracket. Out of air stream plated steel linkage.
 - 1. Ruskin Model SD-60 or approved equivalent.
- B. Round Motor-Driven Smoke Dampers 18" and Under: Frame constructed of 20 gauge galvanized steel, 2 layers of galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers. Stainless steel sleeve bearings pressed into frame.
 - 1. Ruskin SDR-25 or approved equivalent.
 - 2. Use rectangular damper with smooth square/round transitions for dampers over 18" round.
- C. Temperature Class 350°F.
- D. Factory sleeve.
- E. Factory mounted 24V/120V spring return electric actuator.
- F. Electric Damper Actuators:
 - 1. Actuator shall have microprocessor based motor controller providing:
 - a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
 - b. Shall be incapable of burning out if stalled before full rotation is reached.
 - 2. Housing shall be steel and gears shall be permanently lubricated.
 - 3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.
 - 4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper. Actuators shall draw no more than .23A at 120V or 24V running, or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.

- 5. Actuator shall carry a manufacturer's 5-year warranty and be manufactured under ISO 9001 quality control
- 6. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).
- G. Where indicated on drawings, or where required by the sequence of controls, provide factory mounted blade position switches to indicate fully open and fully closed.
- H. Damper actuator shall fail open/close upon loss of control air.
- I. UL 555S & Class II.

2.6 COMBINATION FIRE/SMOKE DAMPERS:

- A. Rectangular Fire/Smoke Dampers: 16 gauge galvanized steel frame, type 304 stainless steel side seals, combination silicone/galvanized steel edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel parallel acting blades, square or horizontal plated steel axles, out of airstream in-jamb linkage with stainless steel pivots, factory sleeve, caulked and attached to damper in accordance with UL fire damper requirements.
 - 1. Ruskin FSD-60 or approved equivalent.
 - 2. Ruskin FSD-60V or approved equivalent where axles must be vertical.
- B. Round Fire/Smoke Dampers 18" Diameter and Smaller: 20 gauge galvanized steel frame/integral sleeve, 2 layer galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers, stainless steel sleeve bearings pressed into frame, retaining plates in accordance with the UL listing.
 - 1. Ruskin FSDR-25 or approved equivalent.
 - 2. Use rectangular damper with smooth square/round transitions for dampers over 18".
- C. Paint sleeve with red enamel finish.

Edit Note: Use "D" for most jobs. Coordinate voltage. Edit out electric actuator when pneumatic is available.

- D. Provide factory mounted 120V/24V electric actuator and electric heat actuated manual reset release device. The damper shall at all times be connected to the actuator. The damper closure shall be controlled to not less than 7 seconds and no more than 15 seconds. Release device shall be set at 165°F, unless otherwise noted. Replaceable, fusible elements are not acceptable. Actuator shall be suitable for 20 psi control air.

Edit Note: Use "E" only for projects requiring remote operation during fire conditions, such as an engineered smoke control system. Specify the reset panel and/or fire fighters control panel under either the Fire Alarm or Temperature Control Section. Coordinate with Electrical.

- E. Provide factory mounted pneumatic spring return actuator, 120V/24V electro pneumatic valve, and an automatic reset thermal release device set to close the damper at 165°F/212°F. In

addition, provide a second manual reset thermal release device set to close the damper when the duct temperature is above the damper's degradation temperature. Provide factory mounted and wired terminal strip to allow field connection of normal and override circuits. "Normal" circuit shall be through both thermal release devices, "override" circuit shall bypass first thermal release device but shall include second high limit device. The damper shall at all times be connected to the actuator. Damper closure shall be controlled to not less than 7 seconds and not more than 15 seconds. Replaceable fusible elements are not acceptable. Actuator shall be suitable for 20 psi control air.

F. Electric Damper Actuators:

1. Actuator shall have microprocessor based motor controller providing:
 - a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
 - b. Shall be incapable of burning out if stalled before full rotation is reached.
2. Housing shall be steel and gears shall be permanently lubricated.
3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.
4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper.
5. Actuators shall draw no more than .23A at 120V or 24V running, or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.
6. Actuator shall carry a manufacturer's 5-year warranty and be manufactured under ISO 9001 quality control.
7. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).

G. Where indicated on the drawings or indicated in the sequence of control, provide factory mounted blade position switches to indicate fully open and fully closed.

H. Damper actuator shall fail close upon loss of power/control air.

I. 1 1/2 hour or 3 hour rating as required by construction type.

J. UL 555, 555S, Class II, 350°F.

K. Suitable for vertical or horizontal mounting.

L. Leakage not greater than 10 CFM per square foot at 1" W.C. pressure differential.

2.7 TURNING VANES:

A. Fabricated Turning Vanes: Provide fabricated 22 gauge, single blade or 24 gauge double bladed 4-1/2" radius, 3-1/4" spacing turning vanes and type 2, 4-1/2" wide runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards" Fig 2.3.

B. Do not use trailing edge turning vanes.

2.8 DUCT HARDWARE:

- A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
- B. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
- C. Quadrant Locks: Provide for each manual volume damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.9 DUCT ACCESS DOORS:

- A. Access Doors for Low Pressure Rectangular Duct: Construct of same or greater gauge as ductwork served, provide double wall insulated doors for insulated ductwork. Exposed insulation adhered to door is not acceptable. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. All access doors shall have gasket and will be air tight. Provide one side hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors. Where a hinged door can not be fully opened a removable door may be used.
- B. Access Doors for Medium and High Pressure Rectangular Duct: Insulated double wall round door and frame arranged for "Spin-In" installation, with continuous gasket in frame for door. Leakage of less than .5 cfm at 6" W.G.

Flexmaster "Inspector Series Spin Door" or equivalent.
- C. Access Doors for Round Duct 20" and Less: Sandwich type door, constructed of an insulated double wall outer door connected to gasketed inner plate carriage bolts with hand knobs, and formed to fit the radius of the duct.

Ductmate "Sandwich" or equivalent.
- D. Access Door for Round Duct Greater Than 20": 18" round insulated double wall access door in gasketed frame, attached to duct section similar to tee fitting.
- E. Access Doors for Flat Oval Duct: Use door specified for medium and high pressure rectangular duct in flat portion, use door specified for round duct in curved portion.

2.10 FLEXIBLE CONNECTIONS:

- A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment. Shelf life shall be verified to not exceed six (6) months. Any sign of cracking on interior or exterior shall be cause for replacement immediately.
- B. Use the following product types for each application accordingly:
 - 1. Indoor Equipment Non-Corrosive Air Systems: Heavy glass fabric, double-coated with DuPont's NEOPRENE, non-combustible fabric, fire retardant coating with good

resistance to abrasion and flexing. Fabric shall be 30 oz per square yard, capable of operating at -10°F to 200°F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventglas" Model as manufactured by VentFabric, Inc.

2. Outdoor Equipment Non-Corrosive Air Systems (exposed to weather and sun): Heavy glass fabric, double-coated with DuPont's HYPALON, non-combustible fabric, fire retardant coating with superb resistance to sunlight, ozone and weather which has documented 20-year-old exposure tests. Fabric shall be 26 oz per square yard, capable of operating at -10°F to 250°F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventlon" Model as manufactured by VentFabrics, Inc.
3. High Temperature Non-Corrosive Air Systems: Heavy glass fabric coated with silicone rubber, non-combustible fabric, fire retardant coating, capable of operating and maintaining flexibility between temperatures of -25°F to 500°F. Fabric shall be 16 oz. per square yard, waterproof, air tight, 6 inches wide, complies with NFPA 90, UL Standard #214. "Ventsil" Model as manufactured by VentFabrics, Inc.

2.11 AIR BLENDERS:

- A. Air blender(s) shall be of the type, size, pressure drop and capacity as scheduled and shown on the drawings.
- B. All units shall be factory built and tested, and shall be installed in strict accordance with manufacturer's recommendations and as shown on drawings.
- C. Fabrication shall be of .080 gauge aluminum, and all welded construction.
- D. Units shall be completely fixed devices, with no moving parts, that shall be capable of providing mixed air temperature within +/- 6 degrees F. standard deviation from the theoretical mixed air temperature.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the Engineer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.
- B. Install turning vanes in square or rectangular 90 deg. elbows in supply, return and exhaust air systems, and elsewhere as indicated.
- C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

- D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.
 - E. Provide duct access doors whether shown or not for inspection and cleaning upstream of all coils, fans, automatic dampers, fire dampers (minimum 16" x 24" in ducts larger than 18"), fire/smoke dampers, duct smoke detectors and elsewhere as indicated. Review locations prior to fabrication. Provide multiple access doors for large ductwork to provide adequate reach to equipment.
 - F. Install fire dampers and smoke dampers in accordance with manufacturers instructions.
 - G. Provide fire dampers and smoke dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction.
 - H. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing.
 - I. Provide balancing dampers on high pressure systems where indicated. Use splitter dampers only where indicated on Drawings.
 - J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. Provide matching flanged backing frame with flexible connector where flanged fan connections are provided.
- 3.3 COORDINATION:
- A. Coordinate with installers of other work to ensure that operators, reset devices, and fusible links are accessible at all fire, smoke, and fire/smoke dampers.
 - B. Show access space on coordination drawings. Locate over lay-in ceilings and above corridors wherever practical.
 - C. Order right/left/top/bottom arrangement as required to minimize field modifications.
- 3.4 FIELD QUALITY CONTROL:
- A. Operate installed ductwork accessories after installation to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
 - B. After installation, test every fire and fire/smoke damper for proper operation, provide letter to the Architect/Engineer certifying this work is complete and all dampers are functioning properly.
- 3.5 ADJUSTING AND CLEANING:
- A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
 - B. Label access doors in accordance with Division-15 section "Mechanical Identification".
 - C. Final positioning of manual dampers is specified in Division-15 section "Testing, Adjusting, and Balancing".
 - D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.6 EXTRA STOCK:

- A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION 15910

SECTION 15932 - AIR OUTLETS AND INLETS

PART 1- GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.
- B. Types of air outlets and inlets required for project include the following:
 - Ceiling air diffusers.
 - Wall registers and grilles.
 - Louvers.
- C. Refer to other Division 15 sections for ductwork, duct accessories; testing and balancing; not work of this section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".
 - 2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".
 - 3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".
 - 4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.
 - 5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".
 - 6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
 - 7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:
 - 1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
 - 2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.
 - B. Samples: Submit 3 samples of each type of finish furnished.
 - C. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.
 - D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 15.
 - E. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 15.
- 1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:
- A. Deliver air outlets and inlets wrapped in factory- fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
 - B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 1. Diffusers, Registers and Grilles:
 - a. Anemostat Products Div.; Dynamics Corp. of America.
 - b. Price
 - c. Carnes Co.; Div. of Wehr Corp.
 - d. Krueger; Div. of Philips Industries, Inc.
 - e. Titus Products Div.; Philips Industries, Inc.
 - f. Metal-Aire
 - g. Carnes
 - h. Nailor
 2. Louvers:
 - a. Air Balance
 - b. American Warming & Ventilating, Inc.
 - c. Arrow United Industries, Inc.
 - d. Pottoroff
 - e. Louvers & Dampers, Inc.
 - f. Penn Ventilator Co., Inc.
 - g. Ruskin

2.2 CEILING AIR DIFFUSERS:

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems, which will contain each type of ceiling air diffuser.
- D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on air device schedule.

2.3 REGISTERS AND GRILLES:

- A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction, which will contain each type of wall register and grille.
- D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on air device schedule.

2.4 LOUVERS:

- A. See Section 10200, LOUVERS AND VENTS, for louvers and vents provided by Division 10.

OR

General: Except as otherwise indicated, provide manufacturer's standard 4" deep X 4" height stationary, stormproof blade type louvers with aluminum bird screen where shown; of size indicated; constructed of aluminum/galvanized steel and components as indicated, and as required for complete installation. Air Balance Model FL-445J (galvanized steel, 4" deep, 45°, fixed style J blades). Louvers shall be Air Balance Model EL-445K (extruded aluminum, 4" deep, 45° fixed style K blades). [LIST MANUFACTURER AND MODEL] or approved equivalent.

- B. Performance: Provide louvers that have a minimum of 50% free area, and a maximum pressure drop through the free area of not more than 0.075" for each type as listed in manufacturer's current data.

- C. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate, which will contain each type of louver.
- D. Materials: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.
- E. Louver Screens: On inside face of exterior louvers inside face of exhaust air outlet and outside face of outside air intake louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.
- B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.
- C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules.

3.3 SPARE PARTS:

- A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

END OF SECTION 15932

SECTION 15933 - AIR TERMINALS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.
- B. Types of air terminals specified in this section include the following:
 - 1. Central Air Terminals
 - a. Shutoff Single Duct
 - b. Reheat
- C. Refer to other Division 15 sections for related work in addition to the requirements of this section.
- D. Refer to Division-16 sections for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on air terminals. Include disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
 - 1. Control wiring between field-installed controls and air terminals.
 - a. Control wiring specified as work of Division-15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. ADC Compliance: Provide air terminals, which have been tested and rated in accordance with ADC standards, and bear ADC Seal.
 - 2. ARI Compliance: Provide air terminals, which have been tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bear ARI certification seal. Hot water coils shall be tested and rated in accordance with ARI Standard 410.
 - 3. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

- A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; schedule showing drawing designation, room

location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

- B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.
- C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.
- D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 15.
- E. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Division 15.

1.4 DELIVERY, STORAGE, AND HANDLING:

- A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.
- B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Terminals:
 - a. Titus Products Div.; Philips Industries, Inc.
 - b. Anemostat Products Div.; Dynamics Corp. of America.
 - c. Tempmaster
 - d. Carnes Co.
 - e. Corp.; Sub. of United Technologies Corp.
 - f. Trane (The) Co.
 - g. Metal-Aire
 - h. Krueger

2.2 AIR TERMINALS:

- A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.
- B. Air terminal units shall be low pressure drop, single duct/ dual-duct throttling type pressure independent and suitable for use in low/medium pressure variable volume [and] constant volume/dual duct air distribution systems.

- C. Casing shall be minimum 22 gauge galvanized steel construction with internal acoustical coated 1/2" thick, 1-1/2 lb. density fiberglass insulation and inlet and outlet duct connections. Provide gasketed and insulated access doors for air terminals with internally mounted serviceable components, including actuators and fan motors.
- D. Internal damper blade shall be extruded aluminum or 18 gauge steel with keyed fit shaft and nylon bushing. Damper shall seal against gasketed stops maximum 2% leakage at 3.0" S.P. All mechanical parts shall be galvanized or non-ferrous. Alternate damper design as produced by the Trane Company as acceptable.
- E. Hot water heating coils shall be designed for 200 psig maximum working pressure and 200°F maximum operating temperature. Coil shall be serpentine-type, constructed of 1/2" O.D. copper tubes mechanically bonded to aluminum fins; galvanized steel casing.
- F. Provide label on each air terminal unit, indicating plan designation, unit size, cfm range and settings and calibration curve.
- G. Provide a pressure independent pneumatic cross or ring-shaped flow sensor with velocity pressure pickup points for measuring inlet airflow. The sensor shall maintain control accuracy with the same size inlet duct in any configuration. Single point hot wire anemometer or straight line pneumatic sensors are not acceptable. Provide gauge ports in flow sensor tubing.

2.3 CONTROLS:

- A. Air terminal unit manufacturer shall mount DDC velocity controller and actuator provided by temperature control manufacturer. See Section 15971/15973.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 COORDINATION:

- A. The contractor is responsible for determining the position of controls, actuators, and access. Coordinate each air terminal's position with building elements, piping, conduit, ductwork and other items, order left/right hand units as required and inform all other trades as required. Relocate interfering items or terminal as required to provide proper access if not coordinated beforehand.

3.3 INSTALLATION OF AIR TERMINALS:

- A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.
- B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
- C. Duct Connections: Connect ductwork to air terminals in accordance with Division-15 ductwork sections.

3.4 FIELD QUALITY CONTROL:

- A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.
- B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.5 CLEANING:

- A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

3.6 BALANCING:

- A. See Section 15990. Balancing contractor shall set all air quantity limits, and shall not rely on any factory calibration. Report air quantity as measured by the air terminals velocity pressure pick up, in addition to pitot traverses and outlet readings.

END OF SECTION 15933

SECTION 15971 - DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. The Contractor shall become aware of the Method of Procedure requirements outlined in Division 1. Change orders will not be considered for time associated with Method of Procedure requirements.
- B. General: The Control System Contractor shall provide a complete new modified control system using new control devices to replace existing devices to operate as specified. The contractor shall inspect the existing conditions prior to submitting a proposal. The existing temperature control system control devices, dampers, operators, wiring, conduit, air piping, valves, etc. not being modified and which are no longer utilized, shall be removed, and not abandoned in place.
 - 1. All temperature control devices to be removed shall be returned to the Owner in good condition.
- C. The Control Contractor will be responsible for all installation, programming, commissioning, testing and performance verification.
- D. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.
- E. It shall be a digital, distributed microprocessor-based system with a pneumatic and electronic interface, where required. The Control System for this project will be referred to as a Building Automation System (BAS).
- F. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safeties and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable.
- G. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warranty for the BAS. The Control Contractor shall be responsible for supplying and installing all necessary control devices for completing the BAS.
- H. The system shall include all control device, valves, interlocks, field devices, hardware, software, automatic dampers, piping, fittings, wire, conduit, etc., as specified and required and connected so as to perform all functions and operate according to the specified sequences.
- I. The Contractor shall leave operable existing controls in operation until the BAS is tested and proven operative. At that point, and with concurrence from the Owner and the Engineer, the Contractor shall be responsible for removing existing controls that are no longer necessary. Start-up of the BAS system, and any installation work that requires the interruption of the normal operation of any piece of equipment, shall be scheduled with the Owner. If the interruption of the normal operation of any piece of equipment during normal working hours is unacceptable to the Owner, then it shall be scheduled during after hours (night or weekend).
- J. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Architect/Engineer in writing. Unless approved otherwise, all products (including firmware revisions) used in this installation shall have been used in at least twelve (12) projects prior to this installation. The previous sites may be located anywhere in

the U.S.A. This requirement is not intended to restrict the Contractor to the use of any outdated equipment. Therefore, all products used in this installation shall also be currently under manufacture and have available, for at least ten years after completion of the contract, a complete line of spare parts. If the above requirements are mutually exclusive, the Contractor shall include a specific statement to this effect in the Bid.

- K. Refer to other Division 15 sections for installation of instrument wells, valve bodies and dampers in mechanical systems.
 - L. Provide electrical work as required, complying with requirements of Division 16 sections including, but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical connections for equipment. Work includes, but is not limited to, the following:
 - 1. Interlock and control wiring between field-installed controls, indicating devices and unit control panels.
 - 2. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the electrical drawings.
 - 3. Refer to Division 1/16 for mechanical/electrical coordination.
 - M. Control Contractor shall furnish & identify location requirements for all necessary control devices which may be installed by others including the following, but not limited to:
 - 1. Automatic control valves.
 - 2. Flow switches.
 - 3. Outside, return and exhaust air dampers for the supply fan/return fan systems.
 - 4. Modulating dampers.
 - 5. Required wells for insertion thermostats and/or temperature sensing wells.
 - 6. Pressure Sensors.
- 1.2 QUALITY ASSURANCE:
- A. Contractors Qualifications: Firms regularly engaged in installation and commissioning and servicing of digital control equipment, of types and sizes required, whose firm has been in business in similar service for not less than 5 years.
 - B. All work of this Section shall be fully "Year 2000 Compliant". (See Section 15010). All date related data shall use four digit dates. "Windowing" of dates is specifically prohibited.
 - C. Only those manufacturers specified are allowed to bid temperature controls. All bidders shall make available, upon the Owner's request, open book unit pricing of all materials and labor.
 - D. The system shall be installed by competent mechanics, regularly employed by the Temperature Control Contractor.
 - E. All bidders must have installed and completed at least two (2) direct digital temperature control jobs of similar design, size and scope using the same equipment as specified.
 - F. All bidders must have a local office in the area of the project site.
 - G. All bidders must have capabilities of doing component level repairs on all systems, including electronic systems.

- H. No Field Devices shall be multiplexed to a single I/O point unless specified. Each control or sensing point shall be terminated at a unique location on the BAS panel, Slave or Dedicated Controller and be associated with a unique software point on the BAS.
 - I. Codes and Standards:
 - 1. All equipment and the installation shall comply with the requirements of all applicable local and national codes including but not limited to the currently enforced edition of the Uniform Building Code, Uniform Fire Code, Uniform Electrical Code, and all applicable codes of the National Fire Protection Association including the National Electrical Code.
 - 2. Electrical Standards: Provide electrical products, which have been tested, listed and labeled by UL and comply with NEMA standards.
 - 3. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.
 - 4. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
 - J. All bidders must have a minimum of one person dedicated to software generation. This person shall be located in an office local to the project site.
 - K. The equipment and software proposed by the supplier shall be currently in manufacture. No custom products shall be allowed unless required by the Specification. All products shall be supported by the manufacturer for a minimum of 5 years including spare parts, board repairs and software revisions.
 - L. The Temperature Control Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others work.
 - M. It will be the responsibility of the Contractor to work in cooperation with the Owner and with all other contractors and employees rendering such assistance and so arrange his work such that the entire project will be delivered complete in the best possible condition and in the shortest time.
- 1.3 PROPRIETARY INFORMATION:
- A. Project Documentation: All custom software, programs, code, databases, graphic files and drawings (whether hard copy or CADD based files) prepared for this system shall be the exclusive property of the Owner and shall not be reproduced or distributed without prior written permission from the Owner.
 - B. The use or reference to AT&T / Owner any of its subsidiaries or any of the facility automation projects shall not be used by the Manufacturer or Contractor in any promotional media, including advertisements, sale brochures, annual reports and client references or endorsements, without prior written permission from the Owner. The Owner reserves the right to restrict or refuse access to any or all of its facilities.
- 1.4 SUBMITTALS:
- A. Submit in accordance with Division 1 and 15 submittal requirements.

- B. In addition to the requirements set forth in paragraph A above, the following shall be included in the shop drawing submittals including, but not limited to:
1. Product Data: Submit manufacturer's technical product data sheets for each control device furnished, each data sheet shall be labeled indicating its control drawing descriptor and include the following:
 - a. indicating dimensions;
 - b. capacities;
 - c. performance characteristics;
 - d. electrical characteristics;
 - e. finishes of materials;
 - f. commissioning, installation instructions and start-up instructions.
 2. Valve, damper and well and tap schedule showing size, configuration, capacity and location of all equipment.
 3. Control system drawings containing pertinent data to provide a functional operating system and a sequence of operation.
 4. Detailed wiring diagrams.
 5. A floor plan of each area with a detailed new conduit/wiring layout shall be included. The plan shall indicate all conduit locations within $\pm 2'$ of actual installed location. All walls, doors and temperature control devices shall be accurately shown.
 6. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and all control devices. Identify all control points with labeling.
 7. Label each control device with setpoint or adjustable range of control. Provide a bill of materials with manufacturer's part number.
 8. Indicate all required point to point electrical wiring. Clearly differentiate between portions of wiring that are existing and portions to be field-installed.
 9. Provide details of faces of control panels, including controls, instruments, and labeling.
 10. Include verbal description of sequence of operation and reference each device described by schematic symbol used.
 11. Provide a detailed listing of all software program code written for each system.
 12. Provide a point list with database input information to include a point name, address, base and span, action and other required information.
 13. Provide a detailed test plan and procedure for each HVAC system and for each type of terminal unit control including valves. The test plans shall fully define reporting methods, procedure, equipment utilized, milestones for the tests, identifying the simulation programs, and personnel. The test procedures shall be developed from the test plans and shall consist of instructions for test execution and evaluation. A test report form shall be developed for each point and sequence of operation. Commissioning procedures shall be provided for each HVAC system and for each type of terminal unit control system. The procedure shall include setpoint, prop. band, integral, derivative, mode constraints input, output settings, tuning procedures., etc.
- C. Submit manufacturer's installation instructions.

- D. Submittal data and shop drawings shall be prepared and submitted in the following formats:
1. All drawings prepared for the project shall be developed using the Autocad CADD program, most current version, (or a CADD package capable of producing AutoCadd "DXF" compatible format files).
 2. All submittals data shall be the same size for any group of information and shall be in a three screw and post binder. (NO EXCEPTIONS). All the information shall be indexed and tabbed with reference to the specific section of these specifications.
 3. The format for different groups of submittal information are as follows:
 - a. Control drawings, building plans (including complete floor plans), schematics and system configurations shall be CADD prepared drawing, bound and indexed. Drawings that cannot represent the total information on an individual ANSI size B (11" x 17") drawing, i.e. a building plan, shall be noted with appropriate match lines, cross references and key plans.
 - b. Technical data, sequence of operations, material list, point lists, program listings, I/O schedules, operator's and programmer's manuals, etc. shall be type written, original product data sheets or CADD prepared drawings, ANSI size A or ANSI size B.
 4. Upon completion of the project and acceptance of systems the contractor shall provide to the Owner one set of hard copy as-built shop drawings and diskettes.
- E. Shop drawings shall include riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical will be allowed where appropriate.
- F. When the Architect/Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.
- G. Contractor agrees that shop drawing submittals processed by the Architect/Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Architect/Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use. The Contractor shall be responsible for space requirements, configuration, performance, changes in bases, supports, structural members and openings in structure, and other apparatus that may be affected by their use.
- H. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.
- 1.5 DELIVERY, STORAGE AND HANDLING:
- A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent any equipment

damage, and to eliminate all dirt and moisture from equipment. Store all equipment and materials inside and protected from weather.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND CONTRACTORS:

- A. Subject to compliance with requirements, install one of the following systems:
 - 1. Siemens
 - 2. Johnson Controls
 - 3. Honeywell

2.2 GENERAL PRODUCTS DESCRIPTION:

- A. The Building Automation System (BAS) shall be capable of integrating multiple building function including equipment supervision and control, alarm management, energy management, and historical data collection and archiving. All products and materials installed shall be suitable for the intended application requirements including but not limited to:
 - 1. Accuracy
 - 2. Rangeability
 - 3. Temperature and pressure ranges
 - 4. Shut-off pressures
 - 5. Differential pressures
 - 6. Repeatability
 - 7. Materials of construction suitable with the environment and/or media in which they are in contact with
 - 8. Code compliance
 - 9. Velocities.
- B. The BAS shall consist of the following:
 - 1. Standalone DDC panels
 - 2. Standalone application specific controllers (ASCs)
 - 3. Portable Operator's Terminals
 - 4. Personal Computer Operator Workstations
 - 5. High Speed Communication Network (LAN)

The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

- C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- D. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC panel or combination of panels on the network without dependence upon a central processing device. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.
- E. Shared points will not be allowed.

- F. BAS shall allow third party software to operate on personal computer workstation without any degradation to the controls operating normally.

2.3 NETWORKING/COMMUNICATIONS:

The design of the BAS shall network operator workstations and Standalone DDC panels as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via the local area network, or auto-dial telephone line modem connections, or via a combination on the two networking schemes.

A. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
2. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.
 - a. Access to system data shall not be restricted by the hardware configuration of the BAS. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.
3. General Network Design: Network design shall include the following provisions:
 - a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.
 - b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.
 - c. Detection and accommodation of single or multiple failures of either workstations, DDC panels, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
 - d. Message and alarm buffering to prevent information from being lost.
 - e. Error detection, correction, and retransmission to guarantee data integrity.
 - f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
 - g. Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.

1. Control Processes
 2. Energy Management Applications
 3. Alarm Management
 4. Historical/Trend Data for all points
 5. Maintenance Support Applications
 6. Custom Processes
 7. Operator I/O
 8. Dial-Up Communications
 9. Manual Override Monitoring
- C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:
1. Digital Inputs for status/alarm contacts
 2. Digital Outputs for on/off equipment control
 3. Analog Inputs for temperature, pressure, humidity, flow and position measurements
 4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
 5. Pulse inputs for pulsed contact monitoring
- D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors and actuators.
- The system architecture shall support a minimum capacity of [%] for all types of DDC panels, and all point types included in the initial installation.
- E. Serial Communication Ports: Standalone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals. Standalone DC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.
- F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for analog control type points. These override switches shall be operable whether the panel is powered or not.
- G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.
- H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
- I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.
- J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with the latest IEEE Standard 587.

1. Provide ISLATROL active tracking filters or equal, which provides both high and low voltage transients, non-linear characteristics, capable of instantaneously responding to spikes or transients without degradation to the filter or its performance. Power protection device shall be UL listed and have a reliability in excess of 100,000 hours of mean time between failures.
 2. Signal wiring shall not be installed in same conduit as high voltage wiring.
- K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

Should DDC panel memory be lost for any reason, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port., or via telephone line dial-in.

2.5 SYSTEM SOFTWARE FEATURES:

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms.
 - a. Two Position Control
 - b. Proportional Control
 - c. Proportional plus Integral Control
 - d. Proportional, Integral, plus Derivative Control
 - e. Automatic Control Loop Tuning
2. Equipment Cycling Protection; Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

- C. Energy Management Applications: DDC panels shall have the ability to perform any or all of the following energy management routines.

- Time of Day Scheduling
- Calendar Based Scheduling
- Holiday Scheduling
- Temporary Schedule Overrides
- Optimal Start
- Optimal Stop
- Night Setback Control
- Enthalpy Switchover (Economizer)
- Peak Demand Limiting
- Temperature Compensated Load Rolling
- Fan Speed/CFM Control
- Heating/Cooling Interlock
- Cold Deck Reset
- Hot Deck Reset
- Hot Water Reset
- Chilled Water Reset
- Chiller Sequencing

All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

- D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:
 - a. Any system-measured point data or status
 - b. Any calculated data
 - c. Any results from other processes
 - d. User-Defined Constants
 - e. Arithmetic functions (+, -, *, /, square root, exp, etc.)
 - f. Boolean logic operators (and, or, exclusive or, etc.)
 - g. On-delay/Off-delay/One-shot timers.
2. Process Triggers: Custom processes may be triggered based on any combination of the following:
 - a. Time interval
 - b. Time of day
 - c. Date other processes
 - d. Time programming
 - e. Events (e.g., point alarms)
3. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network.

In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.
4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly

send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.
- E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.
1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
 2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.
 3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.
 4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

Each standalone DDC panel shall be capable of storing a library of a least 250 Alarm Messages. Each message may be assignable to any number of points in the panel.
 5. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.
- F. Historical Data and Trend Analysis: A variety of Historical Data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
1. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs.

The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be store for the past 24 hours to allow the user to immediately analyze equipment performance and all problem related events for the past day. Point History files for binary input or output points and

analog output points shall include a continuous record of the last ten status changes or commands for each point.

2. Control Loop Performance Trends: Standalone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one second increments for verification of control loop performance.
 3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of one minute to two hours, in one-minute intervals, shall be provided. Each standalone DDC panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 500 data samples.
 4. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party person computer applications.
- G. Runtime Totalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.
1. The Totalization routine shall have a sampling resolution of one minute or less.
 2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.
- H. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons, etc.).
 2. The Totalization routine shall have a sampling resolution of one minute or less.
 3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
- I. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.
1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
 2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.6 APPLICATION OF SPECIFIC CONTROLLERS - HVAC APPLICATIONS:

- A. Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

- B. Each ASC shall operate as a Standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Points shall not be shared between controllers.
 - C. Each ASC shall have sufficient memory to support its own operating system and data base including:
 - 1. Control Processes
 - 2. Energy Management Applications
 - 3. Operator I/O (Portable Service Terminal)
 - D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network.
 - E. Application Specific Controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include, but not be limited to, the following:
 - 1. Display temperatures
 - 2. Display status
 - 3. Display setpoints
 - 4. Display control parameters
 - 5. Override binary output control
 - 6. Override analog setpoints
 - 7. Modification of gain and offset constants
 - F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller..
- 2.7 AHU CONTROLLERS:
- A. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion.
 - 1. Large Air Handling Units
 - a. Mixed Air-Single Path
 - b. Mixed Air-Dual Path
 - c. 100% Single Path
 - d. 100% Dual Path
 - B. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.
 - C. AHU Controllers shall have a library of control routines and program logic to perform the sequence operation as specified in the Execution portion of this specification.
 - D. Occupancy-Based Standby/Comfort Mode Control: Each AHU Controller shall have a provision for occupancy sensing overrides. Based upon the contract status of either a manual wall switch or an occupancy sensing device, the AHU Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

- E. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.
 - F. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.
- 2.8 OPERATOR INTERFACE:
- A. Basic Interface Description:
 - 1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.
 - 2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and applications data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.
 - 3. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze the system performance. If the interface is unable to display several different types of displays at the same time, the BAS Contractor shall provide at least two operator stations.
 - 4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.
 - a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.
 - b. A minimum of five levels of access shall be supported:
 - 1) Level 1 = Data Access and Display
 - 2) Level 2 = Level 1 + Operator Overrides
 - 3) Level 3 = level 2 + Database Modification
 - 4) Level 4 = Level 3 + Database Generation
 - 5) Level 5 = Level 4 + Password Add/Modification

- c. A minimum of 50 passwords shall be supported at each DDC panel.
 - d. Operators will be able to perform only those commands available for their respective passwords. menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.
 - e. User-definable, automatic log-off timers from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.
5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
- a. Start-up or shutdown selected equipment
 - b. Adjust setpoints
 - c. Add/Modify/Delete time programming
 - d. Enable/Disable process execution
 - e. Lock/Unlock alarm reporting for each point
 - f. Enable/Disable Totalization for each point
 - g. Enable/Disable Trending for each point
 - h. Override PID loop setpoints
 - i. Enter temporary override schedules
 - j. Define Holiday Schedules
 - k. Change time/date
 - l. Enter/Modify analog alarm limits
 - m. Enter/Modify analog warning limits
 - n. View limits
 - o. Enable/Disable demand limiting for each meter
 - p. Enable/Disable duty cycle for each load.
6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:
- a. A general listing of all points in the network
 - b. List of all points currently in alarm
 - c. List of all off-line points
 - d. List all points currently in override status
 - e. List of all disabled points
 - f. List all points currently locked out
 - g. List of all items defined in "Follow-Up" file
 - h. List all weekly Schedules
 - i. List all Holiday Programming
 - j. List of limits and deadbands

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

- B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
 2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
 3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
 - a. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (i.e. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (i.e. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
 - b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawings program to allow the user to perform the following:
 - 1) Define symbols
 - 2) Position and size symbols
 - 3) Define background screens
 - 4) Define connecting lines and curves
 - 5) Locate, orient, and size descriptive text
 - 6) Define and display colors for all elements
 - 7) Establish correlation between symbols or text and associated system points or other displays.
 - c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aid the operator in the analysis of the facility.

To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.
- C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the Operator. System definition and modification procedures shall not interface with normal system operation and control.
1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - a. Add/Delete/Modify Standalone DDC Panels
 - b. Add/Delete/Modify Operator Workstations
 - c. Add/Delete/Modify Application Specific Controllers
 - d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
 - e. Add/Delete/Modify alarm reporting definition for each point.
 - f. Add/Delete/Modify control loops
 - g. Add/Delete/Modify energy management applications

- h. Add/Delete/Modify time and calendar-based programming
 - i. Add/Delete/Modify Totalization for every point
 - j. Add/Delete/Modify Historical Data Trending for every point
 - k. Add/Delete/Modify custom control processes
 - l. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
 - m. Add/Delete/Modify dial-up telecommunication definition
 - n. Add/Delete/Modify all operator passwords
 - o. Add/Delete/Modify Alarm Messages
2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.

Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

- a. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:
 - 1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
 - 2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
 - 3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
 - 4) Time Delays
 - 5) Process Control Outputs such as start/stop control points, analog adjust points, etc.
 - 6) Process Calculation Outputs
 - 7) Text file Outputs and Advisories
 - b. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to allow the development of all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
 - c. Sequencing, Testing, and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desired control response and calculation results via graphical displays and hardcopy printouts.
3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.
4. Database Save/Restore/Back-Up: Back-up copies of all standalone DDC panel databases shall be stored in at least one personal computer operator workstation.

5. Continuous supervision of the integrity of all DDC panel databases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective database to restore proper operation. Database back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a DDC panel's database.
- D. Personal Computer Operator Workstation Description: Personal Computer Operator Workstations shall be provided for command entry, information, management, network alarm management and database management functions. All real-time control functions shall be resident in the Standalone DDC panels to facilitate greater fault tolerance and reliability.
1. Computer workstation shall have the following minimum hardware configuration.
 - a. Intel Pentium 200 mHZ Processor
 - 1) 32 mB RAM
 - 2) 3.8 GB IDE hard drive (11 ms avg. maximum seek time)
 - 3) PCI Video ATI Mach 64 with 4 mB VRAM
 - 4) 256 KB Cache memory
 - 5) 200 watt power supply (minimum)
 - 6) 17" VGA color monitor 1280x1024 resolution and .26 dot pitch
 - 7) 3.5" diskette drive
 - 8) 5.25 diskette drive
 - 9) 250 mB internal Colorado Memory Systems tape back-up (9.5 mB/minute), with 2 blank tapes
 - 10) Keyboard
 - 11) MS-DOS 6.22 or higher
 - 12) 28.8 K bPS internal fax/modem
 - 13) Compatible LAN Network Card
 - 14) MS Office '97 Professional
 - 15) MS Windows '95
 - 16) 3 year warranty on parts
 - 17) Power director with surge suppression
 - 18) 12x CD-Rom (built-in)
 2. The workstation shall be as manufactured by Gateway model P5-200 or the following other compatible approved manufacturers, subject to performance parameters listed above:
 - a. IBM
 - b. Compaq
 - c. Micron
 - d. Hewlett-Packard
 3. The workstation shall also include a HP1200C color printer with cable, one set of color and monochrome toner cartridges. Printer shall have a minimum of 4 mB of memory.
- E. A portable laptop computer shall be provided to the Owner upon completion of the project. The laptop computer shall include all necessary hardware and software to allow remote access of the complete BAS on or off the site via a modem phone line communication connection.

The laptop computer shall be configured to monitor, access, and make adjustments to the system and operate the same as the computer workstation described above.

The laptop computer shall have the following minimum configuration:

1. NEC Versa
 2. Intel P5-133 mHZ
 3. 16mB RAM
 4. 12.1" Active color display
 5. Local Video Bus with accelerator
 6. PCMCIA Slots (2) Type II / (1) Type III ports: Parallel, Serial, CRT, PS/2 Keyboard mouse
 7. Lithium Ion battery
 8. 1 GB hard drive
 9. 3.5" 1.44 mB floppy disk drive
 10. Battery charger
 11. 1 spare battery
 12. MS-DOS 6.2 or higher
 13. MS Windows '95
 14. Integral Track Mouse
 15. Targus Universal Case
 16. Built-in 28.8 K bps Fax/Modem
 17. MS Office '97 Professional
 18. 155 V plug-in adapter power supply
- F. Standalone DDC panel Local or Portable Operator's Terminals: Each DDC panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications.
1. There shall be a provision for both permanently mounting the standalone DDC panel Operator Terminal, or using it as a portable handheld unit.
 2. The DDC panel Operator Terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single c\screen dynamic displays depicting entire mechanical systems.
 3. The operator functions provided by the DDC panel Operator Terminal shall include, but not be limited to, the following:
 - a. Start and stop Points
 - b. Modify Setpoints
 - c. Modify PID Loop Setpoints
 - d. Override PID Control
 - e. Change Time/Date
 - f. Add/Modify Start/Stop Weekly Scheduling
 - g. Add/Modify Setpoint Weekly Scheduling
 - h. Enter Temporary Override Schedules
 - i. Define Holiday Schedules
 - j. View Analog Limits
 - k. Enter/ Modify Analog Warning Limits
 - l. Enter/ Modify Analog Alarm Limits
 - m. Enter/ Modify Analog Differentials
 - n. View Point History Files
 4. The DDC panel Operator Terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.

5. Operator access at all DDC panel operator Terminals shall be identical to each other, as well as identical to the PC or Laptop Operator Workstations. Any password changes shall automatically be downloaded to all controllers on the network.
6. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.
7. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the DDC panel Operator Terminal shall change and limit touchpad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touchpad functions.
8. Context-Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.
9. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the DDC panel Operator's Terminal to eliminate cross-reference or look-up tables.
10. In addition to instantaneous summaries, the DDC panel Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30-minute intervals, or a record of the last ten status changes for binary type points.

2.9 MATERIALS AND EQUIPMENT:

- A. General: The Contractor shall provide control products in the sizes and capacities indicated. The existing control system shall remain and be reused as is. Additional controllers, sensors, and devices which are required to make a complete control system shall be the responsibility of the controls contractor.

Select type of damper for each project.

- B. Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, double piece, 22-gauge galvanized steel mechanically joined, zinc plated steel concealed linkage and blade pin, oil impregnated bearings, self compensating stainless steel side seals and silicone blade seals. Leakage rates shall not exceed 10 cfm/ft² at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

OR

Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, 1/16" extruded aluminum air foil blades, zinc plated steel concealed in frame linkage, zinc plated steel blade pin, oil impregnated bronze bearings, self compensating stainless steel side seals, neoprene blade seals. Leakage rates shall not exceed 7 cfm/ft² at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

C. Damper blade operation shall be as follows:

APPLICATION	OPERATION
Modulating Air Volume Control	Opposed Blade
Mixing Plenum	Parallel Blade/Opposed Blade
Isolation/Shut-off Service	Parallel Blade

D. Pneumatic Dampers Operators:

1. All damper operators shall be of the synthetic elastomer diaphragm piston-type and shall be fully proportioning unless otherwise specified. Dampers operators shall have metal bodies. The operators shall have ample power to overcome friction of damper linkage and air pressure acting on the damper blades. The damper operator mounting arrangement shall be outside the airstream wherever possible. The operators shall have external adjustable stops to limit the stroke. The operator linkage arrangement shall permit normally open or normally closed positions of the damper as required by the sequence of operation.
2. Damper operators on modulating dampers that are sequenced with other control devices shall have a pilot positioner of the full relay type with an interconnecting linkage to provide mechanical feedback so as to accurately position and control the damper.
3. Pneumatic Type Damper: Size each actuator to operate dampers with sufficient reserve power to provide smooth modulating action or 2-position action as specified.

E. Automatic Control Valves:

1. Control valves shall have equal percentage plugs.
2. Control Valve Construction:
 - a. Small Valves 1/2" through 1": Valves shall be constructed with a cast brass body and screwed ends. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless steel stem shall be provided. Bonnet, cage and the stem and plug assembly shall be removable for servicing. Body rating shall be 400 psi at 150 deg. F.
 - b. Valves - 1/2" through 2": Valves shall be constructed with a cast brass body and screwed ends. For special duty, valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.
 - c. Valves - 2 - 1/2" and above: Valves shall be constructed with a cast iron body and have flanged connections.

Include the paragraph below where required.

- d. For motorized plug, butterfly and ball valves, the operator shall be provided with the valve by the valve manufacturer. See Section 15100.
 - e. Steam control valves shall be suitable for superheat conditions where superheat may occur in operating system conditions.
3. Control Valve Operators/Actuators:
- a. All automatic control valves shall be fully proportioning with modulating plugs for equal percentage of linear flow characteristics and shall be provided with actuators of sufficient power for the duty intended. Valve body and actuator selection shall be sufficient to handle system pressure which will be encountered on the project.
 - b. Where required by the sequence of operation, valves shall be capable of being sequenced either with other valves or other pneumatically actuate devices. Where such sequencing is required the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift can cause an overlap, a pilot positioning operator shall be furnished.
 - c. Actuator housings shall be cast aluminum, with synthetic rubber diaphragm, spring return type.
4. Temperature control contractor and manufacturer shall size control valves for proper control characteristics for each application.
5. Water control valves shall be sized for a pressure drop between 4 to 6 psig at full flow condition.
6. Select valves to fail in normally open or closed position as follows:

Edit the following very carefully.

- a. Terminal Heating Devices:
 - 1) Offices, Public Areas and schools
N.O.
 - 2) Computer equipment rooms, telephone equipment rooms,
N.C.
- b. Chilled Water Service:
 - 1) Offices, Schools
N.C.
 - 2) Computer equipment rooms, telephone equipment rooms,
N.O.

c. All Pre-Heat (Outside Air) Coil:

N.O.

d. or as dictated by life safety, freeze protection, fire or temperature protection.

2.10 INPUTS:

A. All input accuracies required by this section shall be end-to-end (from sensing point to BAS display). End-to-end accuracy includes all errors due to the sensor, transmitter, wiring and BAS signal measurement and A/D conversion.

B. Thermistors or solid state sensors shall be provided for temperature sensing applications except where accuracies or ranges required cannot be met by these devices, RTD's shall be used. The sensors shall be powered by the BAS panel or Dedicated Controller. The solid state sensors shall be accurate to within $\pm 0.5^{\circ}\text{F}$. over the following ranges and meet the following requirements:

1. Room Type Instruments: 50°F to 100°F . For room space applications: Sensor shall be surface recessed mounted in a plastic aluminum/stainless cover with an insulated baseplate & vandelproof screws.

Each thermostat have the following features:

- a. Exposed/Concealed setpoint adjustment dial with temperature graduation indication.
- b. Exposed graduated temperature indicating thermometer.
- c. All/Public area thermostats shall be provided with a plastic/stainless steel vented, lockable security cover.

2. Duct & Plenum Applications: -30°F . to 240°F . Supply, return, exhaust or mixed air averaging type, which shall have an extended element of sufficient length to cover the entire duct cross-section with a minimum of three passes. If a single averaging thermistor of sufficient length to meet the preceding are not available then two or more sensors and AIs shall be used and averaged in software.

3. Water Temperature Applications: 30°F to 230°F .

C. Where RTD's are required, they shall be 1000 ohm platinum type and be supplied with a 4-20 mA DC transmitter. The sensor and transmitter shall be a single unit. They shall be accurate to within $\pm 1.0^{\circ}\text{F}$. over the range of 32°F . to 600°F .

D. Where thermocouples are required, they shall be type J and be supplied with a 4-20 mA DC transmitter. They shall be accurate to within $\pm 2.0^{\circ}\text{F}$ over the range of 32°F to 1300°F .

E. Provide matched temperature sensors for applications which require both inlet and outlet temperatures of any device.

F. Thermowells shall be monel, brass or copper for use in copper water lines; and 300 series stainless steel for all other applications.

G. Outdoor Air Temperature Transmitter:

1. Provide Vaisala temperature probe with membrane filters and UV stabilized solar radiation shield. Probe shall have a temperature measuring range of -40°F. to +120°F. with an accuracy of ± 0.54 °F at 68°F. temperature probe shall be capable of a continuous temperature operating range of -40°F. to +120°F. Provide necessary transmitter for output signals.
 2. Provide 1 spare set of protective filters for each transmitter Viasala No. 17039.
- H. Pressure Sensors, Transmitters and Differential Switches:
1. Pump/Liquid (wet) differential pressure switches shall be as manufactured by BARKSDALE with neoprene diaphragm, stainless steel internal parts, NEMA 4 housing.
 2. Air Differential Pressure Transmitters shall be Modus model T30 or T40 (as required) with an accuracy of $\pm 1\%$ of range (including nonlinearity and hysteresis), solid state circuitry, no moving parts, capacitance principle capable of sensing positive, negative and differential pressures. Transmitter shall have 4-20 mA output signal and be powered by the control system or dedicated controller and capable of withstanding momentary overpressure of 8 times the pressure range.
 3. Differential air pressure switches for filter or proof of airflow status shall be Dwyer Series 1910, with automatic reset, SPDT.
 4. Hi-static pressure safety switches shall be Dwyer series 1900 MR, with manual reset, snap switch, SPDT, with repetitive accuracy within 3%.
 5. Water/Liquid/Steam/Refrigerant Pressure Transmitter: Kele & Associates Model SA, stainless pressure transmitter with 4-20 mA output signal, watertight enclosure with stainless steel bulkhead fitting, accuracy of $\pm 1\%$ full scale, temperature compensated, 300 series stainless steel wetted parts.
 - a. Provide Model 47S pressure snubber for applications where the transmitter is subjected to fluid hammer, pressure surge or pulsation.
 - b. Provide Model PT steam syphon pigtail steam applications and where the fluid temperature is higher than the maximum operating temperature rating of the transmitter.
 6. Air and Vacuum Pressure Transmitter: Kele & Associates Model P100GTE, solid state, 4-20 mA signal, with a full scale accuracy of 1%.
- I. Output Devices:
1. Control Relays: Control relay contacts shall be rated for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Provide with LED to indicate status.
 2. Analog output transducers shall be of positioning type with position feedback and control internal to the transducer. As an option, position feedback may also be input to the BAS.
 3. Analog output transducers shall meet the following requirements:

- a. 4-20 mA DC output.
 - b. Two-pipe electromechanical design or microprocessor-based design.
 - c. 3-15 psi output range adjustable to a 0-20 psi range minimum.
 - d. Linearity, repeatability and hysteresis no greater than 2% of full scale.
 - e. Air capacity of 1000 SCIM minimum.
 - f. Air consumption of no more than 100 SCIM.
 - g. Pressure gauges shall be installed on the branch and supply lines.
 - h. Acceptable transducers are the Bellofram T1000, Fairchild T5700, Johnson N6810, Mamac EP-310 or an equivalent.
4. Electronic analog output transducers shall output a signal to match the controlled device. The Contractor shall be responsible for verifying the required signals for all controlled devices. Transducers shall be completely solid-state with no mechanical parts.
 5. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Relays shall be equipped with coil transient suppression, devices to limit transients to 150% of rated coil voltage. Delayed contact openings or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of $\pm 2\%$ of setting.
 6. Latching Relays: Latching Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.
- 2.11 GAUGES:
- A. General: Provide air pressure gauges for indication of supply and control air pressure at each branch for all control valve sizes 1" and larger, as well as all control dampers, all controllers, relays and EP and PE switches.
 - B. Air pressure gauges shall be a minimum of 1-1/2" diameter, resistant to effects of shock, pulsation and vibration, with a full scale accuracy of $\pm 2.5\%$.
 - C. Round receiver gauges for continuous indication of analog values shall be 4" dial face instruments. Gauges shall be calibrated in appropriate units for the variable being measured and shall operate through their full range on a change in air pressure from 3 to 15 psi. Accuracy shall be plus or minus 1/2% of full scale.
- 2.12 POSITIONERS:
- A. Positive positioning relays shall be provided on valve actuators and damper operators when required to provide sufficient power, sequencing and repeatability.

- B. Provide for smooth gradual operation over operating span adjustment of 0 to 15 psi and start point adjustment of 3 to 10 psi.
- 2.13 CUMULATORS, SWITCHES AND MISCELLANEOUS ITEMS:
- A. Provide all cumulators, switches and other miscellaneous items as may be required for the successful operation of the temperature regulation systems specified herein and/or shown on Drawings.
 - B. Cumulators shall be of the positive and gradual acting type.
 - C. Provide suitable indicating plates with all switches.
 - D. Pressure/Electric switches shall be micro switch type.
 - E. Range shall be 0 - 20 psi with electrical rating of 10 amperes minimum for 115V/1/60.
- 2.14 POWER MONITORING:
- A. General: Provide current switches, current transducers, voltage transducers, current transformers as required to meet the specified sequence of operation and indicated below.
 - B. Current Operated Switches: AC current switch, Neilsen - Kuljian Model PD50AC, or PD75, solid state, 5 year warranty, three selectable ranges for optimum adjustability and resolution. Provide external current transformer where required.
 - C. Current Transducers: AC current to DC current output, $\pm 0.5\%$ accuracy, 4-20 mA output signal, Kele and Associates Model 4CMA. Provide external current transformer where required.
 - D. Voltage Transducers: Kele & Associates Model PVM or LVM as required for each application, $\pm 1/2\%$ accuracy, 4-20 mA DC output.
- 2.15 VIBRATION MONITORING:
- A. Vibration Switch: Kele & Associates Model 502 vibration switch, frequency range of 120 to 30,000 CPM, 3 second time delay to prevent triggering due to transients 4-20 mA output signal, capable of being wired for automatic reset or latch and remote reset, $\pm 5\%$ accuracy, alarm setpoint and shutdown limit, NEMA 4 enclosure, capable of being mounted with the sensitive axis in any plane including inverted position and a velocity range of .15 to 1.5 in/sec.
- 2.16 GAS DETECTION SENSORS:
- A. Carbon Dioxide Sensor: SELECT WALL OR DUCT MOUNT. Viasala GMD20 (Duct) GMW20 (Wall); , designed to monitor CO₂ levels, in accordance with ASHRAE Standard 62-1989, 4-20 mA output, accuracy at 20°C $< (20\text{ppm} + 1.5\% \text{ of reading})$, 0-2000 PPM range, adjustable to 20000 ppm.
 - B. Refrigerant Leak Detection: MSA Instruments. "CHILLGARD RT" leak detection system, monitor and multipoint sequences, complies with ASHRAE Standard 15-1992, 0-100 PPM, 10% reading, 0-100 PPM linear reading, $\pm 2\%$ of full scale for 100-1000 PPM, 1 PPM sensitivity for R-123, resolution of 1 PPM, capable of 6 sampling points, suitable for either R-123, R-134A, R-22, ammonia, complete with alarm relays, 4-20 mA analog output, NEMA 4 enclosure, calibration kit, audible horns, zero & span gas scrubber.
 - C. Oxygen Monitor Sensor: Davis Instruments Teledyne Model 335, with a range of 0-25% O₂, 0.5% sensitivity of full scale, $\pm 2\%$ accuracy at constant temperature, solid state electronics,

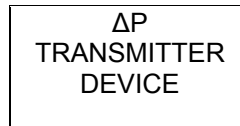
two adjustable alarm setpoints and form C relay contacts, built-in audible and visual indication, AC powered, NiCad battery back-up and battery test switch. Provide calibration equipment and span gas.

2.17 TEMPERATURE CONTROL CABINETS:

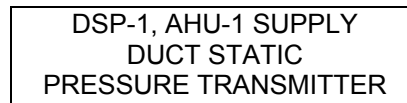
- A. General: All controllers and field interface devices shall be installed in control panel cabinet/enclosure as described below.
- B. Cabinets shall be UL listed, 14 gauge furniture grade steel, finished with baked enamel painted finish inside and out, cabinet doors shall have piano hinge and standard key cylinder locking latch.

Cabinets shall include Lexan windows to view controls without opening the door.

- C. Control panels located outdoors shall be NEMA 4X.
- D. All devices installed in or on the control cabinet shall be labeled with a fixed mounted, color contrasted, engraved laminated plastic tags, including describing the function of the device, similar to the following example:



Label



- E. All pneumatic devices within the panel shall be factory prepiped. A "pneumatic terminal" numbering system shall be applied to pneumatic lines within a panel with aforementioned numbers matching pneumatic terminals shown on control diagrams. This feature is required to assist system checkout and service.
- F. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.
- G. Mount control panels adjacent to associated equipment on vibration free walls or free standing steel angle supports or "Unistrut" support stand.

2.18 VARIABLE FREQUENCY DRIVES:

- A. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.
- B. Automatic operation shall be from a 4-20 milliamp signal follower, which shall follow a transducer signal. The signal follower shall contain the following design features.
 - 1. Shall accept a transducer output signal and condition it to produce a speed reference signal for the inverter.

2. Minimum speed adjustment (Zero to Maximum RPM).
 - C. Wire all safeties to operate both in hand and auto positions as well as drive and by-pass sections.
 - D. Provide communication cabling and interface necessary to forward VFD computer communication information to and from the BAS/VFD. See Section 15040.
- 2.19 HIGH & LOW TEMPERATURE LIMIT CONTROL DEVICES:
- A. Provide PENN A70 series or equal, DPST, manual reset, two isolated sets of contacts. Control responds to temperature along any one foot of entire element.
 - B. Vapor charged sensing element shall be calibrated for altitude of project site.
 - C. Provide multiple limit control devices as required to provide complete and full coverage of the entire coil face area and/or duct cross section area.
- 2.20 ELECTRICAL MATERIALS:
- A. All wiring shall be installed in conduit. See Division 16 for conduit installation requirements. Where wiring is exposed in plenum locations (i.e. open cable tray, wiring shall be plenum rated.
 - B. Conduit and Conductors: Types as indicated in Division 16 sized per Division 16 except for low-voltage twisted pair or single jacketed cable (1/2" minimum). All low voltage conductors shall be stranded 22 gauge copper minimum; twisted pair.
 - C. Fittings per Division 16: Bushings or nylon insulated throats are not required for jacketed cables.
 - D. All J-boxes shall be identified and labeled per Division 16.
 - E. All conductors and cables shall be labeled per Division 16.
 - F. Conduit and box supports shall be per Division 16.
 - G. Junction boxes shall be of types and sizes as indicated in Division 16.
 - H. Conduits shall not exceed 40% maximum fill for single conductor and jacketed cables.
 - I. Fiber Optic Cable:
 1. Acceptable fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140. Only glass fiber is acceptable, no plastic.
 2. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.
 - J. Coaxial Cable:
 1. Coaxial cable shall conform to RG62 or RG59 rating.
 2. Provide plenum rated coaxial cable when running in return air plenums.

- K. All temperature control panels & controllers shall be provided with fuse protection on both incoming power load supply (primary side) and on low voltage side of control transformer (secondary side).
 - L. Provide lightning arresters Kele & Associates Model 392-SVSR2 or equal, at all points where communication cables exit or enter the building.
 - M. All communication cabling shall be shielded type.
- 2.21 END SWITCHES:
- A. All end switches shall be NEMA rated contacts and NEMA 4X enclosure, either SPDT, DPDT DPST as required to meet the sequence of operation, complete the points list and necessary interlocks or safeties control wiring. End switches shall be as manufactured by Cutler-Hammer or Allen-Bradley.
 - B. All end switches shall be designed and configured to provide positive indication of a control device (i.e. damper or valve) position for the service intended.

PART 3- EXECUTION

3.1 INSTALLATION:

- A. The Contractor shall install all equipment, control air piping/tubing, conduit and wiring parallel to building lines.
- B. All automatic control valves and control dampers furnished by the Temperature Control Contractor shall be installed under his supervision by the Mechanical Contractor.
- C. GENERAL INSTALLATION REQUIREMENTS:
 - 1. Spare conductor capacity, equal to a minimum of (2) additional sensors shall be provided to each underfloor sensor and pendant type sensors.
 - 2. Wiring shall be installed in conduit throughout.
 - 3. Horizontal runs of conduit, trays, tubing or wiring shall be hung from structural members using new supports, or where feasible, utilizing existing temperature control conduit and piping. The Contractor shall verify adequacy of existing systems and warrant these systems as if they were new. Single runs of conduit, tubing or wire shall be by clevis ring and all thread rod. Multiple runs shall be by "Trapeze" or "Unistrut" supports. "Plumber's Strap" shall not be allowed. Maximum distance between supports shall be per the NEC. Existing supports shall only be used upon written concurrence by the Architect, Engineer or Owner.
 - 4. All vertical runs of conduit or tubing shall be through new core drills. Existing core drills may be used if approved by the Owner. The installation shall be supported above each floor penetration using clamps to "Unistrut".
 - 5. All wire that enters or leaves a building structure shall be installed with lightning protection per NEC.
 - 6. All wire terminations shall be with compression type round hole spade lugs under a pan head screw landing; Stay-Kon or equivalent. All wire splices shall be with compression

type insulated splice connectors or properly sized "wire-nut" connectors. Hand twisted, soldered and/or taped terminations or splices are not acceptable.

7. Where tubing, wiring or conduit penetrate floors or walls, sleeves with bushings shall be provided for tubing and wires. The conduit or sleeve opening shall be sealed with fire proof packing so the smoke and fire rating of the wall or floor is maintained.
8. All the material installed under this contract must be mounted on, or supported from the building structure or supports furnished by this Contractor.

3.2 ENCLOSURES:

- A. The wiring within all enclosures shall be run in plastic trays. Wiring within BAS panels may be run using adhesive-backed tie wraps.
- B. Mount all enclosures, including those which house BAS Panels, Slaves and Field Device Panels, so that the top of the enclosure does not exceed six feet, six inches (6'-6"); and the center of any keypad/LCD combination does not exceed five foot, six inches (5'-6") from the floor or is less than four feet zero inches (4'-0") from the floor.
- C. Field Device Panels contain related Field Devices such as relays, control power (24V) transformers, output transducers, etc., that are outboard of the BAS Panels or Dedicated Controllers. Each Field Device Panel shall be mounted within an enclosure. The enclosures shall be provided with lockable latches that will accept a single key common to all Field Device Panels, BAS Panels and Slaves.

3.3 EXISTING CONTROLS:

- A. Remove all existing controls, controllers, receiver/controllers, thermostats, sensors, Field Devices, gauges, etc.; and all associated wiring, piping and mounting hardware whose functions are being replaced by the BAS.

3.4 INSTALLATION PRACTICES:

- A. The Contractor shall install and calibrate all Field Devices, sensors and transducers necessary for the complete operation of the I/O points described herein.
- B. Sensors shall be removable without shutting down the system in which they are installed.
- C. All immersion sensors shall be installed in new, welded thermowells supplied by the Contractor. Existing thermowells may be reused with concurrence from the Owner. Coordinate any required shutdown with Owner.
- D. Thermistor wire leads shall be permanently terminated at panels or controllers with wire clamps.
- E. Where none exist, furnish and install pressure/temperature gauges adjacent to each immersion type sensor.
- F. Sensors shall be installed with the use of a wet or hot tap without draining the system if required.

3.5 IDENTIFICATION:

- A. All control J-boxes, conduit and wiring shall be labeled.

- B. Electrical devices, wiring, conduit and J-boxes shall be labeled and identified as required by Division 16.
 - 1. As a minimum regardless of Division 16 requirements, all temperature control J-box covers shall be painted blue [] in color on both sides of cover.
 - C. Identification shall be provided for all enclosures, panels, junction boxes, controllers or Field Devices. Laminated, bakelite nameplates shall be used. The nameplates shall be 1/16-inch thick and a minimum of 1 inch by 2 inches. The lettering shall be white on a blue [] background with minimum 1/4-inch high engraved letters. The nameplates shall be installed with pop rivets.
 - 1. All new devices will be tagged.
 - D. Thoroughly clean the surface to which the label shall be applied with a solvent before applying the identification. Use an epoxy to affix the identification in addition to any adhesive backing on the identification.
 - E. The plan code designation shown on all shop drawing identification shall be consistent with the contract documents.
 - F. All I/O Field Devices that are not mounted within Field Device Panel enclosures shall be identified with engraved plastic laminated nameplates installed so that they are visible from ground level.
 - G. The identification shall show the designation used on the record documents and identify the function such as "mixed air temperature sensor" and "fan status DP switch".
 - H. Calibration settings shall be marked with paint or indelible ink.
- 3.6 LOCATIONS:
- A. All sensing devices and locations shall be located by the Contractor as shown on the submittal shop drawings with final review by the Engineer.
 - B. Wall mount space sensors shall be mounted five (5) feet above finished floor. Pendant mount space sensors shall be mounted eight (8) feet above finished floor.
 - C. Enclosures housing Field Devices shall be located immediately adjacent horizontally to the BAS panels or Slaves which are being interfaced to.
- 3.7 VALVES, WELLS, FLOW SWITCHES AND AUTOMATIC CONTROL DAMPERS:
- A. The Controls Contractor shall have his control equipment on the project site when required and give the Owner 24 hours written notice when systems must be shut down for installation.
- 3.8 TEMPERATURE SENSORS:
- A. Temperature controls trades shall verify all wall mounted temperature sensors locations with the Architect/ Engineer/Owner in order to avoid interference with wall mounted and space furnishings.
 - 1. Where interferences require moving the temperature sensor more than two feet, consult with the Architect/Engineer for relocation.

- B. Temperature sensors shall be mounted on suitable insulated base and secured to the wall in such a way as to be easily removed from wall without damage to the sensor.
- C. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60" (1524 mm) above floor.

3.9 EQUIPMENT PROTECTION AND COORDINATION:

- A. Where existing walls are penetrated with conduit or piping, provide a fire stop assembly which meets or exceeds the original rating of the assembly. Refer to Division 15.
- B. Extreme care must be exercised while working in existing facilities and around operating equipment, particularly sensitive telephone switching and computer equipment. Close coordination with the Owner is required for the protection of this operating equipment from dust, dirt and construction material while maintaining the operational environment for the equipment. Under no circumstances shall the power or environmental requirements of the operating equipment be interrupted during the installation and check-out without submitting to the Architect, Owner and Engineer for approval.
- C. A detailed Method Of Procedure (MOP) stating the steps to be taken, time schedule and impacted systems for the service interruption shall be submitted to the Architect for approval prior to beginning work. Refer to Division 1 and Division 15 for requirements.

3.10 CLEANUP:

- A. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of all grease, plaster, dust, or other foreign materials.
- B. Upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings. Use extreme care in cleaning around telephone switching and computer equipment and under no circumstances shall water or solvents be used around this equipment.
- C. At the completion of the work and at the end of each work day, remove from the building, the premises, and surrounding streets, etc., all rubbish and debris resulting from the operations and leave all equipment spaces absolutely clean and ready for use.

3.11 SOFTWARE, DATABASE AND GRAPHICS:

- A. Software Installation: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.
- B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.
- C. Color Graphics: Unless otherwise directed by the Owner, the Contractor will provide color graphic displays for all systems which are specified with a sequence of operation, depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

3.12 TEMPERATURE CONTROL DRAWINGS:

- A. Upon completion of project and after record drawings of the temperature controls have been prepared and reviewed, the Contractor shall provide one (1) complete set of temperature controls drawings at each temperature control panel. Each set of drawings shall be laminated in a plastic coating. The drawings shall consist of only those control functions associated with the specific control panel and any relevant or pertinent network interface information.

The laminated drawings shall have a grommet connection attached to a metal cable or chain which is mechanically fastened to the temperature control cabinet.

3.13 START UP AND TESTING:

- A. Prior to Beneficial Use of the BAS, the Contractor shall supply to Architect/Engineer two (2) debugged printouts of all software entered into the BAS. Also supply all user's programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:

1. Point data base.
2. All custom control programs written in the BAS control language.
3. All parameters required for proper operation of BAS control and utility firmware such as start-stop routines, etc.
4. Printouts or plotted detailed copies of the complete interactive system graphics.

- B. The software printout shall be fully documented for ease of interpretation by the Architect/Engineer and Owner, without assistance from the Contractor. English language descriptions shall be either integrated with or attached to the BAS printout. Specifically, the following shall be documented:

1. All point (I/O and virtual) names.
2. All BAS Programming Language commands, functions, syntax, operators, and reserved variables.
3. Use of all BAS firmware.
4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable for use in this documentation requirement.
5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, etc.

- C. Documentation that was supplied as part of the submittals need not be submitted at this time.

- D. Upon review of software, a point-to-point test of the BAS installation shall commence. The Contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. This procedure shall occur during off hour periods. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the BAS shall be provided by and operated by the Contractor. The Engineer and/Owner will be present to oversee, observe, and

review the test. Demonstrate compliance that system functions per the Sequence of Operation.

1. Upon review of the point-to-point demonstration, the Contractor shall start up the BAS by putting all controlled equipment in automatic and enabling software. Contractor shall commence final software and overall BAS hardware/software debugging.
 2. The point-to-point demonstration shall include any existing BAS equipment if it affects the operation of the equipment included under this contract.
 3. As a minimum, existing conditions shall be maintained during system changeover.
- E. Final acceptance of the BAS is contingent upon a hardware/software system test. All groups of points that yield a system of control shall be tested for compliance with the sequences of operation. Included in the test, but not limited to, shall be:
1. BAS loop response. The Contractor shall supply a trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set point which represents a change in the actuator position of at least 25% of its full range. The sampling rate of the trend shall be from one to three minutes depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that does not yield temperature control of $\pm 0.2^{\circ}\text{F}$ or humidity control of $\pm 3\%$ RH shall require further tuning by the Contractor.
 2. Interlocks and other sequences.
 3. BAS control under HVAC equipment failure.
 4. HVAC operation under BAS equipment failure.
 5. Battery backup.
 6. BAS control under power failure/restart.
 7. Reset schedules.
 8. BAS alarm reporting capability.
- F. A detailed test report as defined under Submittals shall be provided indicating its completion and proper system operation.
- G. The BAS will not be accepted as meeting the requirements of Beneficial Use until all tests described in this section have been performed to the satisfaction of both the Architect/Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor shall be exempt from the Beneficial Use requirements if requested in writing by the Contractor and concurred by the Owner and Architect/Engineer. Such tests shall be performed as part of the BAS warranty.
1. A typed written document stating that the system has been fully checked out on a point by point basis shall be submitted to the Architect/Engineer. All documentation associated with the check out shall be included.

3.14 PROJECT RECORD DOCUMENTS:

- A. The Contractor shall be responsible for updating all existing Project Record Documents associated with the Scope of Work outlined in the Drawings and Specifications.
- B. Prior to final completion of the installation, prepare a complete set of record drawings on a clear and legible set of ANSI size 'B' (11" x 17") mylar reproducible prints. The content, format and procedure of the submittal shall be as described by the General Conditions.
- C. Provide one laminated and framed set of control drawings for each new BAS control panel and one for the Facility Control Room, locate as directed by the Engineer.
- D. Prior to final completion of the installation, prepare three (3) operation and maintenance manuals. The information is to be inserted in the existing operation and maintenance manuals or provided in a tabbed and indexed, 3 screw and post binder. The information shall include:
 1. Operator's manual with step-by-step procedures for logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware parameters.
 2. Programmer's manual with complete description of the custom control language and associated editor, including sample written programs. Provide complete sets of all programming forms, applications memorandums, and addenda to the programmer's manual. All software or firmware algorithms shall be completely described and documented.
 3. Maintenance, Installation, and Engineering manual(s) that clearly explains how to debug hardware problems, how to repair or replace hardware, preventive maintenance guidelines and schedules, calibration procedures, and how to engineer and install new points, panels, and Operator Interfaces.
 4. Documentation of all software. List separately all software parameters that will need updating by the Owner such as, though not limited to, holiday, seasonal and start/stop schedules, comfort and duty cycling schedules.
 5. All programs, code, databases, graphic files, CADD drawings and symbol libraries generated for operation of the system shall be included as a part of the system documentation. This information shall be submitted both in hard copy bound format and magnetic media format.
 6. Input/output schedules, data sheets, and all other items required under Submittals. Describe all regular maintenance that will need to be performed on the BAS hardware. List replacement parts with part numbers.
 7. Complete original issue documentation and software diskettes for all third party software furnished and installed as a part of the system or required for the operation of the system including text editors, control language program and compiler, database managers, graphics and CADD packages, operating systems and communications software.
 8. Complete original issue documentation, installation and operational manuals and supporting software for all third party hardware furnished and installed as a part of the system or required for the operation of the system including remote terminals, user's computer workstation, monitors, graphics and memory boards, printers and modems.

9. During the warranty period, all copies of the drawings and manuals shall be updated to include all hardware and software changes. A final update at 1 year shall be provided to the Owner.
 - E. All of the above documentation shall record both the equipment installed under this contract and the exact termination to all other existing control or BAS equipment.
 - F. The record drawings shall document the complete existing control system. This includes all mechanical equipment in work area which has automatic control.
- 3.15 WARRANTY:
- A. The Warranty period shall begin on the date of beneficial use completion as authorized by the Architect/Engineer and Owner in writing. Beneficial use shall not occur before the Contractor has performed the tests required. With these requirements met, beneficial use shall not occur until, in the opinion of the Architect/Engineer, the BAS is sufficiently complete to be utilized for the purposes for which it is intended.
 1. The warranty start date shall not begin until all phases of the Project are complete, i.e., the Project shall have a single warranty start date.
 - B. The BAS system shall be guaranteed to be free from defects in material and workmanship and in software design and operation for a period of the warranty after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure the proper operation of, and to provide all required current and preventive maintenance. This warranty shall become effective starting the date of Beneficial Use completion.
 1. The hardware warranty shall include all equipment which has been purchased by the Contractor. The existing hardware is not subject to the warranty requirements.
 2. All software work completed by the Contractor, associated with existing hardware, is subject to the warranty requirements outlined herein.
 3. The Contractor shall respond to all 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.
 4. The response time to any problems shall be four (4) hours maximum 24 hours per day, 7 days per week. Corrective action, temporary or permanent shall be made within one business day.
 - C. The Contractor shall perform a monthly on-site or via telephone MODEM inspection of the operation of the system. They shall report to the Owner in writing after each inspection, define any problems with the system and its operation, and define the procedure which will be taken to correct the problem. Contractor shall comment on the possible resolution of any problems that are out of the scope of their Contract.
 1. Any problems shall be corrected as required by the warranty requirements.
 - D. The system shall be polled via the telephone modem for any alarm signals or "abnormal off" messages. Upon receiving such a message the Contractor shall take indicated corrective action.
 - E. The Contractor shall maintain a backup of all BAS software installed in the system. The backup shall be updated monthly or whenever a change to the software is made. A reload of backup software into the system shall be performed by the Contractor immediately upon notifi-

cation by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.

- F. The Contractor shall optimize all control software to assure acceptable operating and space conditions, and peak energy efficiency.
- G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all Project Record Documentation. This includes final updated drawings, software documentation and magnetic media backups that include all changes that have been made to the system during the warranty period.

3.16 TRAINING:

- A. The Contractor shall provide [] hours of training for the building operators. The training sessions shall be broken into [] []-hour sessions. The training session shall be made available to the Owner prior to the end of the warranty period but after final completion of the contract. The session shall be given at the Owner's facility. Scheduling shall be approved by the Owner. The training shall focus on general design, operation, and maintenance procedures of the products installed, though not necessarily the specific system designed, and shall cover:
 - 1. Hardware configuration including PC boards, switches, communication and point wiring, and location and installation of all sensors and control devices.
 - 2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.
 - 3. Operation of man-machine interface including logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware/software parameters.
 - 4. Programming the BAS using the editor and the design of custom control software.
 - 5. Recovery procedures from both BAS and HVAC failures.
- B. The Instructor for the above session shall be an employee of the Contractor, who is qualified to provide customer training and applications support.

3.17 SEQUENCE OF OPERATION:

- A. See Section 15975 and points list on drawings.

END OF SECTION 15971

SECTION 15975 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

- A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.
- B. Operating equipment, devices, and system components required for control systems are specified in other Division 15 Controls' sections of these specifications.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS:

- A. Provide control systems consisting of thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified.
- B. Provide necessary materials and field work necessary to connect control components factory supplied as part of equipment controlled, unless specified otherwise. Generally, self-contained valves, filter gauges, liquid level controllers and similar instruments, are not to be installed under this section.
- C. Unless specified otherwise, provide fully proportional components.
- D. Provide all necessary relays and signal boosters to make the system a full and operable system as required by the sequence of operation.

PART 3 - EXECUTIONS

NOTE: Provide normally open control valves for heating system with the exception of animal facilities or special areas, which require a normally closed valve.

3.1 TERMINAL UNITS' CONTROL SEQUENCES:

- A. Hot Water Heating Finned Tube/Baseboard: Provide wall mounted thermostat to automatically modulate a normally open two-way control valve to maintain the thermostat setting. In rooms, which also have a terminal-heating coil, thermostat shall sequence the FTR valve with the heating coil valve to maintain stat set temperature.
- B. Hot water Unit Heater: Provide unit-mounted thermostat to automatically cycle the fan motor to maintain the thermostat setting.
- C. Hot Water Cabinet Unit Heaters: Provide unit-mounted thermostat to automatically cycle the fan motor to maintain the thermostat setting.
- D. Fan Coil Units: Provide wall mounted thermostat to automatically modulate the normally closed cooling coils control valves and the fan shall run continuously to maintain the space thermostat cooling settings.

3.2 TERMINAL BOX CONTROL SEQUENCES:

- A. Variable Air Volume Without Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop or rise in temperature below or above set point, the thermostat shall modulate the airflow between minimum and maximum scheduled air quantities to satisfy the thermostat set point.
- B. Variable Air Volume with Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in room temperature below thermostat set point, the thermostat shall modulate the airflow minimum scheduled air quantity to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the thermostat shall modulate the reheat coil normally open two-way control valve and increase the air flow to satisfy thermostat set point. On rise in temperature above the thermostat set point, the thermostat shall close the normally open two-way control valve and modulate the airflow to maximum scheduled air quantity.
- C. Variable Air Volume With Reheat Interlocked With Finned Tube Radiation: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in temperature below cooling set point, the thermostat shall modulate the airflow to minimum scheduled air quantity to satisfy cooling set point. On further drop in temperature below heating set point, the thermostat shall modulate the VAV box reheat normally open two-way heating control valve and the finned tube radiation normally open control valve to satisfy heating set point.

3.3 AIR HANDLER CONTROL SEQUENCES:

A. Air Handling Unit []

- 1. The air-handling unit shall be controlled by a local DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.
- 2. Whenever air handling unit air fan is started, the outside and exhaust air dampers shall open to their minimum positions and the supply and return/exhaust shall cycle on through an interlock.
- 3. The supply fan speed shall be modulated by the duct static pressure controller through the local control panel and the variable frequency drive.
- 4. The return fan speed shall be modulated through the local control panel and variable frequency drive to maintain a fixed (adjustable) air flow differential between supply and return air quantities as sensed by the supply and return air flow measuring stations.
- 5. Below an outside air temperature of 55°F (adjustable), the outside air, return air and exhaust air dampers shall modulate to maintain a 55°F (adjustable) mixed air set point.
- 6. Above an outside air temperature greater than the temperature of the return air, the dampers shall set minimum outside air conditions.
- 7. Under minimum outside air conditions, the damper shall modulate to maintain the constant outside air quantity as scheduled and as sensed by the outside airflow measuring station.
- 8. When the supply air temperature falls to below 55°F, the preheat glycol coil pump shall cycle on and the preheating glycol normally open/closed control valve shall modulate to maintain set point.

9. When the supply air temperature rises to above 55°F, the chilled water control valve shall modulate to meet set point.
10. When the air temperature downstream of the preheat coil is 40°F or less, the supply and return air fans shall continue to run/cycle off, the outside air and exhaust air dampers shall close 100% and the return air damper shall open 100% coil circulating pump shall continue to run, the normally open/closed control valves shall open 100% to primary water flow and an alarm shall be sent to the Engineer's office/_____.
11. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off and the outside air, return air and exhaust air dampers shall close, and an alarm shall be sent to the Engineer's office/_____.
12. On detection of high static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off, the outside air and exhaust air dampers shall close 100% the return air damper shall open 100% and an alarm shall be sent to Engineer's Office/_____.

3.4 EXHAUST FANS:

- A. EF-[____]: Exhaust air fan(s) shall run continuously with manual ON/OFF control through the Building Management System [_____].
- B. EF-[____]: On rise in space temperature to above the temperature set point, the intake damper shall open and the exhaust fan shall cycle on. On drop in space temperature, the reverse will occur.
- C. EF-[____]: Exhaust air fan(s) shall be interlocked with the space light switch and shall run only when light switch is into ON position.

3.5 CABINET UNIT HEATERS:

- A. A wall mounted pneumatic type room thermostat will modulate the cabinet unit heater control valve and cycle the fan motor to maintain room thermostat temperature setting.

3.6 BUILDING HOT WATER BOILERS B-1, B-2:

- A. The hot water boilers and its respective two-position control valve will be enabled from the DDC system. Each of the boilers will be sequenced on and off or opened and closed from supply water temperature as required to maintain 180°F. (Adjustable) supply water temperature. Each of the boilers internal factory mounted controls will control the firing of its own boiler. Whenever each boiler is shut off, its respective two-position control valve shall close and whenever each boiler is activated, its respective two-position control valve shall open.
- B. The hot water pumps will be controlled by the DDC panel. If either of the two operating pumps stop, the third pump will be started from differential pressure switch located between the discharge and suction of each pump. Two pumps will run continuously. The DDC panel will generate an alarm if any of the two running pumps stop.
- C. A pump will be started anytime any of the boilers are activated. The pumps shall have hand-off-auto switches and pilot light on indication at the DDC panel for easy manual override operation.

- D. Building hot water supply and return temperatures will be indicated at the DDC panel.

3.7 BUILDING CHILLED WATER CHILLERS CH-1:

- A. The chiller will be enabled from the DDC system. The chiller will be enabled above 55°F. (Adjustable) outside air temperature, or from any one of the air handling units if any one of the air handling unit sequences requires cooling or dehumidification and the outside air intake can not handle the requirement. Hand-off-auto switches and pilot light on indication will be provided at the DDC panel. Differential pressure switches in the chilled water loops will not allow the chillers to start until flow has been proven.
- B. A chilled water pump shall operate anytime there is a call for mechanical cooling.
- C. Once the chiller has been enabled from the DDC system, the chiller will be controlled from its own internal factory mounted controls.
- D. Chilled water supply, chilled water return temperatures will all be indicated at the DDC panel.

END OF SECTION 15975

SECTION 15990 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section covers testing and balancing of environmental systems described herein and specified under Division 15. The testing and balancing of all environmental systems shall be the responsibility of one Testing, Balancing and Adjusting firm.

1. Test, adjust and balance the following mechanical systems and the mechanical equipment associated with these systems:

a. General Systems and Equipment Procedures.

b. Air Side Systems and Equipment

- 1) Supply/Return Air Systems
- 2) General Exhaust/Supply Fans
- 3) Air Handling Units
- 4) General Exhaust Systems
- 5) Cabinet/Unit Heaters
- 6) Unit Ventilators, Furnaces, Packaged Air Conditioning Units

c. Hydronic Systems and Equipment

- 1) Heating/Chilled water systems
- 2) Hydronic coils
- 3) Hydronic Pumps
- 4) Heating Water Boilers

d. Plumbing

- 1) General
- 2) Water heaters

e. Refrigeration Systems and Equipment

- 1) General
- 2) Chillers
- 3) Condensing units

f. Gas Fired Systems and Equipment

- 1) General

g. Electrical Components

- 1) Electric resistance heating
- 2) Manual and magnetic starters
- 3) Variable frequency drives

h. Control Systems and Equipment

- 1) General

- i. Life Safety Systems and Equipment
 - 1) Smoke pressurization, exhaust, and evacuation modes
 - 2) Fire/smoke dampers and detection systems
 - 3) Engine generator systems and equipment

1.2 QUALIFICATIONS OF CONTRACTOR:

- A. The Mechanical Contractor shall procure the services of an independent testing and balancing agency specializing in the testing, adjusting and balancing of environmental systems to perform the above mentioned work. An independent contractor is defined as an organization that is not engaged in engineering design or is not a division of a mechanical contractor entity, which installs mechanical systems.
- B. The actual fieldwork shall be performed by qualified technicians who are currently certified by the Testing, Adjusting and Balancing Bureau (TABB), the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC) certification agencies.
- C. The Testing & Balancing Contractor shall have a minimum of three years experience in testing and balancing mechanical systems.
- D. The Test & Balance Contractor shall have previous experience in testing and balancing variable air volume laboratory fume hood systems in the last two years. Qualification submission must include a detailed resume describing past project experience in laboratory variable air volume systems, a list of projects, including peoples' names, phone numbers and addresses of references.
- E. Testing and balancing work shall be directly supervised by a Registered Engineer and the results attested to by a Registered Professional Engineer on the Testing & Balancing Contractor's staff. The Engineer shall represent the Testing & Balancing Contractor in progress meetings as requested, and shall be available for interpreting all material found in the balance report.

1.3 APPROVAL OF CONTRACTOR:

- A. Following are firms acceptable to do the work:
 - 1. JEDI Balancing
1414 Washburn Street
Erie, CO 80516
(720) 839-5333
 - 2. Air Right Inc.
 - 3. Lawrence H. Finn & Assoc.
 - 4. Griffith Engineering Service
 - 5. JPG Engineering
 - 6. Rocky Mountain Balancing Co.
 - 7. TAB Services, Inc.
 - 8. Complete Mechanical Balancing
 - 9. Double T Balancing Company
 - 10. Controlled Air, Inc.
 - 11. Midwest Engineering
 - 12. Checkpoint Balance

1.4 CODES AND STANDARDS:

- A. ASHRAE: ASHRAE Handbook, Systems Volume, Testing, Adjusting, and Balancing.
- B. NEBB: "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems."
- C. SMACNA: "HVAC Systems-Testing, Adjusting & Balancing."

1.5 PRELIMINARY SUBMITTALS:

- A. Within ten (10) days of award of the contract the Mechanical Contractor shall submit the name of the Test and Balance Contractor who will be performing the work. The submittal shall include a complete list of all technicians who will be performing the field work and include a photocopy of their current certification by either NEBB, AABC, or TABB certification agencies. Only those technicians included in the submittal shall perform the work. Any personnel or staff used to perform the work without prior approval of the Engineer, who are not included in the submittal, shall be grounds for rejecting the test and balance report and the project in whole.
- B. Meet all requirements of Section 15010 as applicable.
- C. Submit a list of all instrumentation to be used on an individual project and include calibration dates. Submit calibration curves. If more than one instrument of a similar type is used, a comparison of individual readings should be made. The variation between instrument readings should not exceed plus or minus 5%.

1.6 FINAL REPORTS:

- A. Refer to Division 1 for supplemental requirements.
- B. The Testing and Balancing Contractor shall submit six (6) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to substantial completion, unless noted otherwise in Division 1. Report contents shall be per Part 3 of this Section.
- C. Meet all requirements of Section 15010 as applicable.
- D. If more than two reports are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.

1.7 SEQUENCING AND SCHEDULING:

- A. Notify Contractor/Engineer/Architect in writing of conditions detrimental to the proper completion of the test and balance work. Provide the Contractor/Architect/Engineer with a copy of the notification.
- B. Prepare a project schedule. Schedule shall indicate critical path of the balancing process and shall incorporate both requirements of other contractors necessary to meet test and balance commitments and process flow of test and balance work. Coordinate with general and mechanical contractors and insert critical steps into project master schedule.

PART 2 - PRODUCTS

2.1 BELTS, SHEEVES, IMPELLERS:

- A. Refer to specific equipment sections and Section 15010 for additional requirements.

- B. The Testing & Balancing Contractor shall coordinate with the Mechanical Contractor to supply correctly sized drive belts and sheeves. Impellers shall be trimmed or replaced by the mechanical contractor and shall be correctly re-sized and coordinated by the Test and Balancing Contractor per the hydronic systems and equipment portion of this section.
- C. The Test & Balance Contractor shall determine the fan belt and sheeve replacement necessary for final balance condition for specified air quantity when the VFD is operating in the by-pass mode for final field conditions, without placing the motor over its nameplate amp rating.

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES:

- A. Testing and balancing shall not begin until the system has been completed and is in full working order and the following project conditions have been determined suitable for start of work.
 - 1. Preliminary Testing & Balancing Contractor requirements shall be ascertained prior to the commencement of work through a review of the project plans and specifications. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices, that they are being installed properly, and in an accessible location for the need. Report in writing any deficiencies to the Contractor/Engineer/Architect immediately.
 - 2. Before any air balance work is done, the system shall be checked for duct leakage (obtain pressure test results), assure filters are installed, verify filters are changed if they are dirty, check for correct fan rotation, equipment vibration, and check automatic dampers for proper operation. All volume control dampers and outlets shall be wide open at this time.
 - 3. Before any Hydronic, domestic water or applicable system balancing work is done, the systems shall be checked for plugged strainers, proper pump rotation, proper control valve installation and operation, air locks, proper system static pressure to assure a full system, proper flow meter and check valve installation. All throttling devices and control valves shall be open at this time.
 - 4. Verify systems do not exhibit excessive sound and/or vibration levels. Report in writing any deficiencies to the Contractor/Engineer/Architect immediately.

3.2 GENERAL SYSTEM AND EQUIPMENT PROCEDURES:

- A. Balance all air and water flows at terminals within +10% to -5% of design flow quantities. Notify Contractor/Engineer/Architect in writing of conditions detrimental to the proper completion of the test and balance work. Provide the Contractor/Architect/Engineer with a copy of the notification.
- B. Pressure relationships indicated on drawings shall take priority over air quantities.
- C. Mark equipment settings with paint, including damper control positions, balancing cocks, circuit setters, valve indicators, fan speed control settings and similar controls and devices, to show final settings at completion of test-adjust-balance work.

- D. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommend by the original installer.
- E. Measure, adjust and report equipment running motor amps and power factor, KW, rated motor amperage, listed motor power factor, voltage, and all nameplate data. Perform these measurements for all equipment operational modes.
- F. Check and adjust equipment belt tensioning.
- G. Check keyway and setscrew tightness. Report any loose screws and notify Mechanical Contractor prior to equipment balancing.
- H. Record and include in report all equipment nameplate data.
- I. Verify that all equipment safety and operating controls are in place, tested, adjusted and set prior to balancing.
- J. Verify that manufacturer start-up has occurred per specification prior to balancing.

3.3 AIR SIDE SYSTEMS AND EQUIPMENT PROCEDURES:

- A. In addition to the procedures identified under each specific heading below, provide general data required by 3.2 above.
- B. Filters shall be restricted to increase pressure drop to 50% of span between initial pressure drop and final recommended pressure drop for setting final airflows for fans. Check fan motor amps with clean filters and simulated loaded filters, and report for each piece of equipment. Equipment shall be supplied with clean filters upon completion of balance. Balance and report air quantities.
- C. Supply/Return Air Systems:
 - 1. Balance and report supply and return diffuser/grille quantities. Air diffusion patterns shall be set as noted on drawings and to minimize objectionable drafts and noise.
 - 2. Provide full pitot traverses in duct mains downstream of supply fans, upstream of return fans, and in each zone duct downstream of a multizone unit. For VAV systems perform these at the system diversity condition (if any). Balance and report air quantities.
 - 3. Provide full pitot traverses at each air terminal or duct coil. For VAV systems, perform these at zone maximum air condition. Balance and report air quantities.
 - 4. Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system.
 - 5. Balance and report the above measurements in all system operational/modes.
 - a. Minimum outside air and 100% outside air economizer mode.
 - b. VAV maximum zone air condition and system diversity condition.
 - c. Unoccupied mode.
 - d. Two-speed fan, both speeds.
 - e. VFD bypass mode and full system demand.

f. General Exhaust/Supply Fans:

D. Adjust CFM to system requirements. For belt drive include sheave and belt exchange to deliver airflow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine the limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for filter loading (as applicable) and shall establish proper duct pressures for operation of zone CFM regulators. For direct drive with speed taps: Set fan speed on tap which most closely approaches design CFM by adjusting the speed control After adjustment, check fans ability to re-start after powering down. Increase setting if required for proper starting.

1. Measure and report static pressures upstream and downstream of all fans.
2. Measure and report fan RPM.
3. Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice.

E. Air Handling Units:

1. Balance and report supply and return fan CFM, upstream static pressure and downstream static pressure.
2. Measure and report static pressure upstream and downstream of all AHU components such as coils, filters (clean and simulated dirty), dampers, etc.
3. After system and fan balance is complete, perform pitot traverses on all coils in 100% heating and cooling modes.
4. Units with economizers shall have all measurements performed and reported at minimum outside air, 100% outside air, and a 50/50% mixed air condition.
5. Units with operation modes for smoke evacuation and/or pressurization shall have all measurements performed and reported for all modes.
6. Balance variable air volume AHU fans for system design diversity. Supply and return fan static pressures shall be optimized for VAV system terminal device pressure requirements. Report fan, motor and VFD information as previously indicated. Verify that an overload condition does not exist when all system VAV boxes are 100% open.
7. Balance all air handling unit coils and report per hydronic, or refrigeration equipment portions of this section.
8. Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice.
9. Balance and report all temperatures of airside and hydronics during normal operating modes.
10. Measure, adjust, set, balance and report outside air, return air and exhaust/relief air quantities for all air handling systems.

Air quantities shall be determined by pitot traverse/direct airflow measuring procedures where ever possible, where duct/inlet conditions do not allow for accurate direct measurement of outside air the following method shall be used:

$$\text{Outside Air CFM} = \frac{\text{Supply Fan Total CFM} - \text{Return Fan Total CFM}}{\text{Return Fan Total CFM}}$$

In addition to the direct measuring of airflow quantities, measure and record outside air, return air and mixed air temperatures, determine thermal/mass energy balance and provide calculations to verify measured airflow quantities. Adjusting and setting the outside air quantity as a percentage of damper position will not be acceptable.

F. General Exhaust Systems:

1. Balance and report exhaust grille quantities. Report objectionable noise.
2. Provide full pitot traverses at each individual exhaust riser and at each exhaust fan. Balance and report.
3. Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system.

G. Cabinet/Unit Heaters:

1. Balance and report entering and leaving air temperature. Report airflow.
2. Balance all coils per hydronic, gas fired or steam equipment portions of this section.

3.4 HYDRONIC SYSTEMS AND EQUIPMENT:

A. Heating/chilled water systems:

1. Hydronic Systems With Meters: The system shall be balanced proportionally using the flow meters. On completion of the balance, the following information shall be recorded in the report: Flow meter size and brand, required flow rate and pressure drop, valve settings on meters with a readable scale, flow rate in both full coil flow and full bypass modes. Contractor shall verify the meters are installed per the manufacturer's recommendations and shall notify the Mechanical Contractor of any deficiencies before utilizing meter.
2. Hydronic Systems Without Meters (thermal or terminal rated pressure drop balance): The system shall be balanced proportionally to the terminal ratings. On completion of the balance the following information shall be recorded in the report: Design entering and leaving water temperature/pressure, final balanced entering and leaving water temperature/pressure drop.
3. For 3-way valve terminals/heat exchangers, set bypass flow to equal coil flow.
4. For primary/secondary systems, set crossover/bride to have constant flow at all conditions.
5. Sample chilled water and report on freeze and burst temperatures of the glycol water solution. Report glycol percentage.

B. Hydronic Coils:

1. Balance, measure and report inlet and outlet air temperatures for cooling and/or heating design air quantities.

2. Balance, measure and report coil water flow, inlet and outlet water pressure and temperature.
 3. Evaporative cooling coils: Measure and report inlet and outlet wet bulb and dry bulb temperature. Measure and report inlet and outlet pressure.
 4. Calculate and report face velocities across chilled water and evaporative cooling coils.
- C. Heat Exchangers:
1. Balance, measure and report water flow for full heating.
 2. Report inlet and outlet water pressures and temperatures for full heating.
- D. Hydronic Pumps:
1. Adjust and balance pumps to provide design system flow rate, and design flow to most remote system location. Trim or replace impellers as necessary to achieve this. Do not induce false head to achieve balance results, without the prior approval of the Engineer. See Part 2 - "Products" of this section.
 - a. Prior to trimming of impellers, notify the Architect/Contractor/Engineer in writing of performance of pumps with and without false head induced.
 2. Report impeller size, flow rate, inlet and outlet water pressure and pump shut-off head. Provide pump curve and operating point in final report. Include compensations for temperature and percentage glycol.
- E. Heating Water Boilers:
1. Verify that the boiler has been properly cleaned, flushed and the burner is operating properly prior to balancing.
 2. Check and report on proper operation of boiler feed pumps.
 3. Confirm automatic and manual air vents are working properly. Vent system as necessary.
 4. Balance, measure and report boiler water flow rate, inlet and outlet temperature and pressure.
 5. Confirm that temperature and pressure safety relief valves are located properly and in working order.
 6. Verify proper operation of emergency power OFF switches.
- 3.5 PLUMBING SYSTEMS AND EQUIPMENT:
- A. General:
1. Check, adjust and set temperature control devices to [110 F] domestic hot water temperature and as indicated on drawings.
 2. Adjust pressure-reducing stations, report downstream system static pressure.
 3. Verify proper location and operation of ASME pressure and temperature relief valves.

4. Measure and report residual pressure at full flow at most remote plumbing fixture; requiring highest operating pressure (usually flush valve water closets).
 5. Verify that most remote fixture has hot water available semi-instantaneously with recirculation system operating. Report.
- B. Booster Pumps:
- a. Measure and report inlet and outlet pressure and flow rate.
 - b. Balance pumps per Hydronic portion of this Section.
- C. Water Heaters:
- a. Measure, set and report inlet and outlet temperatures.
 - b. Balance and report per steam, electric or gas portions of this Section.
- 3.6 REFRIGERATION SYSTEMS AND EQUIPMENT:
- A. General.
- B. Condensing Units (Air Cooled):
1. Measure and report ambient temperature, refrigerant suction and discharge pressure, oil pressure, compressor and fan KW and compressor and fan amps.
 2. Condensing units integral to the air moving equipment shall be measured at minimum outside air.
 3. Perform all measurements at all stages of cooling.
- C. Chillers:
1. Measure, balance and report inlet and outlet chilled water temperature and pressure, ambient temperature, water flow rate, oil pressure, refrigerant suction and discharge pressure, compressor/fan KW and compressor/fan amps.
 2. Verify proper operation of emergency power OFF switches and refrigerant sensors.
 3. Perform all measurements at all stages of cooling.
 4. Coordinate balance process with equipment manufacturer start-up representative.
- 3.7 ELECTRICAL COMPONENTS ASSOCIATED WITH MECHANICAL SYSTEMS:
- A. Manual and Magnetic Starters:
1. Check all new and existing thermal overloads. Identify improperly protected equipment in report. Furnish and exchange thermals as required for proper motor protection.
 2. Motor Control Center Magnetic Starters: Check for correct sizing. Notify Electrical Contractor of discrepancies.

3. Two-speed Starters: In addition to the above, set time delay between changes of speeds for proper operation.
 - a. Verify windings of motor and starter are compatible prior to starting any equipment.
 - B. Variable frequency drives.
 1. Coordinate balance process with equipment manufacturer start-up representative.
 2. Record nameplate data.
 3. Record motor overload setting.
 4. Record full load amps.
- 3.8 CONTROL SYSTEMS AND EQUIPMENT:
- A. General.
 1. Operate all temperature control systems with the temperature control contractor's representative for proper sequence of operation. Be responsible for calibration of flow measurement devices used as input to the temperature control system. All air system flow measurement stations including VAV terminals shall be calibrated against a Pitot tube traverse or air diffuser capture hood. Balancing Contractor shall assure accuracy of all flow measurement devices or shall report their failure to be accurate.
 2. Work with the Controls Contractor to set minimum outside air damper positions.
 3. Work with the Controls Contractor to optimize VAV duct static pressure, VFD pump hydronic system pressure differential and building pressure.
 - B. Temperature Control Compressed Air Systems and Equipment:
 1. Verify and report air pressure at all system equipment quick connects and terminations.
Remove, inspect and clean all system filters/strainers.
 2. Verify system can maintain overrating pressure for 8 hours with air compressor disconnected. Report any noticeable losses in system pressure.
 3. Measure, set and report storage tank air pressure.
 4. Verify that pressure relief valves are in place and operating correctly.
- 3.9 LIFE SAFETY SYSTEMS AND EQUIPMENT:
- A. Smoke Pressurization/Exhaust/Evacuation Mode:
 1. Balance and report measurements of Section 3.3 in this operational mode.
 2. Perform smoke pressurization/evacuation tests in all zones. Doors shall be positioned to simulate normal conditions.
 3. Coordinate with the Fire Department/Authority Having Jurisdiction, Owner and Engineer for smoke test witnessing.

4. Coordinate with the Fire Department/Authority Having Jurisdiction for additional testing requirements. Complete and submit any documentation for Fire Department/Authority Having Jurisdiction final acceptance.

B. Fire/Smoke Dampers and Detection Systems:

1. Verify that each fire/smoke damper closes when the associated duct or space detector is tripped. Verify that air handlers shut down and outside air dampers close as dictated by the control sequence.
2. Verify that air supply units shut down when smoke is detected by the associated duct detector. Verify that outside air dampers and system fire/smoke dampers close as dictated by the control sequence.
3. Report any detectors or dampers that are malfunctioning. Report any discrepancies from the control sequence.

C. Engine Generator Systems and Equipment:

1. For remote radiators, measure and report steady state radiator system flow rate, supply water temperature and return water temperature.
2. Measure and report generator room steady state temperature with generator and room ventilation system running. Report outside air temperature at time of test.

Record pressure relationship of generator room to adjacent spaces and outside.
3. Verify correct sequence of operation of all intake and discharge dampers, supply/exhaust fans, etc.

3.10 SOUND AND VIBRATION:

A. Sound Inspection and Testing:

1. Prior to sound testing, all equipment that can potentially impact sound testing shall be put into operation. Examples include fan coil units, humidifiers, air handling units, and equipment in adjacent mechanical spaces. VFD systems shall be placed at 80% of full speed.
2. Prior to sound testing the mechanical test and balance of all systems shall be completed.
3. Report audible tonal characteristics such as whine, whistle, hum or rumble. Also report time varying sound levels or beats induced from aerodynamic instability, perform this for all rooms.

B. Vibration Inspection and Testing:

1. Prior to vibration testing, all equipment shall be put into operation. On variable speed equipment, testing shall occur at low, medium and high speeds.
2. Prior to vibration testing, the mechanical test and balance of all systems shall be completed.

3. Report excessive vibrations from any equipment. Inspect upstream and downstream duct and piping systems and report excessive vibrations.

3.11 REPORT OF WORK:

- A. The Testing and Balancing Contractor shall submit six (6) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to the Mechanical Contractor's request for final inspection.
- B. A complete reduced set of mechanical contract drawings (showing each system) shall be included in the report with all equipment, flow measuring devices, terminals (outlets, inlets, coils, fan coil units, schedules, etc.) clearly marked and all equipment designated. The test and balance contractor can obtain drawing files from Cator, Ruma, & Associates for development of these drawings. These drawings shall be developed from the system schematic drawings submitted in Preliminary Systematic Procedures.
- C. Data shall be reported per Part 3 of this Section on standard NEBB forms. Generate custom forms that contain the information in this Section when a standard NEBB form does not exist for a piece of equipment. All NEBB forms shall be fully filled out for this report. When additional information is required by this Section, it shall be provided. Report forms with design columns filled out shall be used from the Preliminary Systematic Procedure report submitted previously.
- D. The report shall include a list of all equipment used in the testing and balancing work. This list shall closely resemble the list submitted with the Preliminary Systematic Procedures report with any discrepancies accounted for.
- E. Report systems for excessive sound and vibration per the sound and vibration inspection and testing portions of this specification.
- F. Substantial completion of this project will not take place until a satisfactory report is received. The Testing & Balancing Contractor shall respond and correct all deficiencies within seven (7) days of receiving the Engineer's written review of the balancing report. Failure to comply will result in holding retainage of the final payment until all items have been corrected to the satisfaction of the Engineer.
- G. The report shall be signed by the supervising registered professional engineer and affixed with their registration stamp, signed and dated in accordance with state law.

3.12 GUARANTEE OF WORK:

- A. The Testing & Balancing Contractor shall guarantee the accuracy of the tests and balance for a period of 90 days from date of final acceptance of the test and balance report. During this period, the Testing & Balancing Contractor shall make personnel available at no cost to the Owner to correct deficiencies that may become apparent in the system balance.

END OF SECTION 15990