

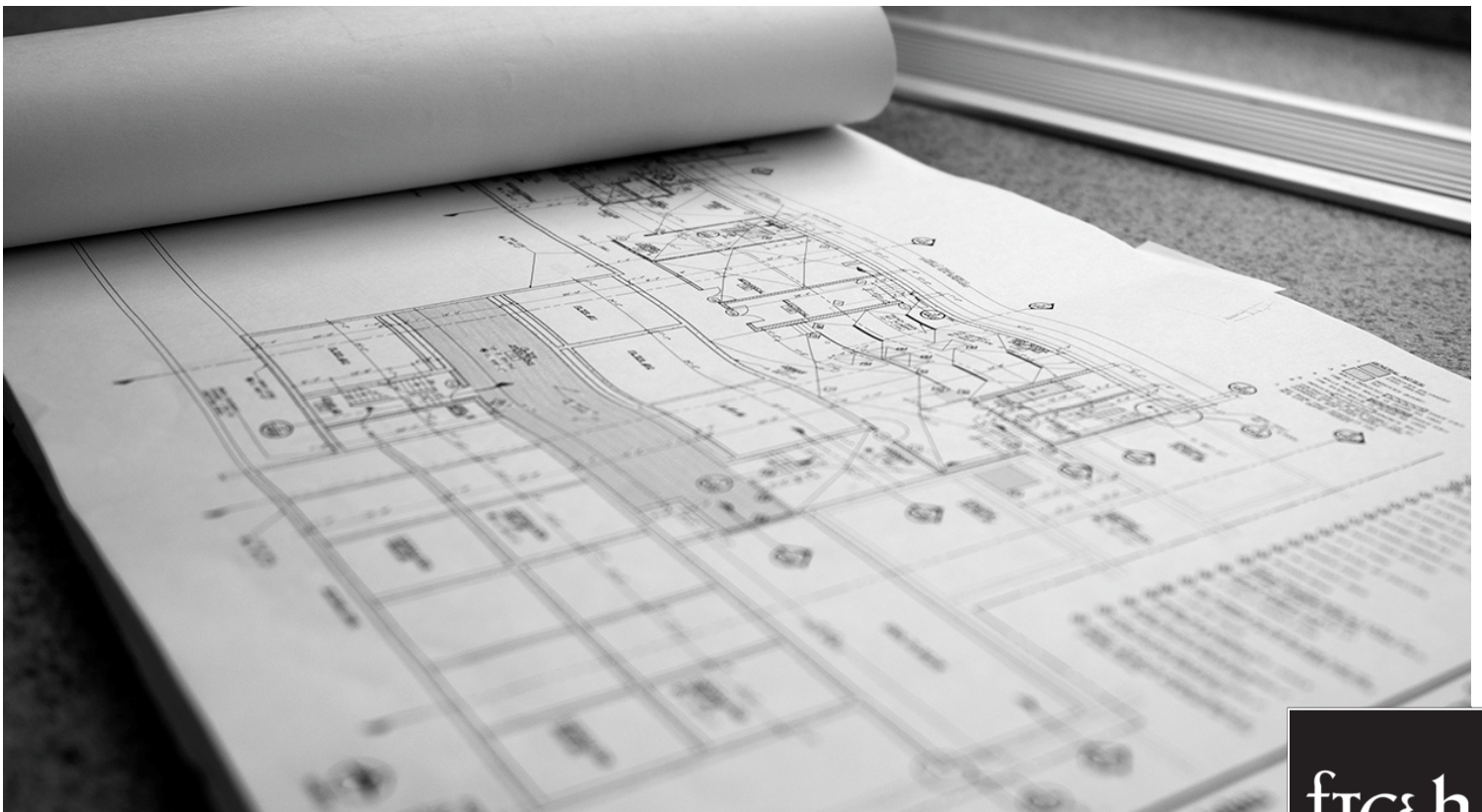
Wayne State University

Pharmacy School Building
Additional Boiler Capacity

259 Mack Avenue
Detroit, Michigan 48201

**BIDS AND
CONSTRUCTION**

Project Manual
WSU Project Number 603-312827
FTCH Project Number 180929



Fishbeck, Thompson, Carr & Huber, Inc.
engineers | scientists | architects | constructors

ftc&h

PROJECT MANUAL
FOR
WAYNE STATE UNIVERSITY

PHARMACY SCHOOL BUILDING
ADDITIONAL BOILER CAPACITY

259 MACK AVENUE
DETROIT, MICHIGAN 48201

FEBRUARY 11, 2019
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ENGINEER

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SECTION 01 18 13 – PROTECTION, RESTORATION AND NOTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes responsibilities for the protection, restoration and notification requirements for surface and subsurface structures, underground facilities and surface improvements.

1.3 NOTIFICATION AND INTERRUPTIONS

- A. Prior to Start of Construction: Arrange for the identification of the locations of existing underground facilities at or contiguous to the Site.

1.4 PROTECTION AND RELOCATION

- A. Be Responsible For:
 - 1. Protection of structures and utilities at or contiguous to the Site in accordance with the General Conditions.
 - 2. Cost of cleaning, repair, relocation, raising, lowering, or replacement of structures and utilities which are damaged as a result of Contractor's operations.
 - 3. Temporary sheeting, bracing, poles, cables, sand fill or other means used to support a structure or utility exposed or endangered by Contractor's operations.
 - 4. Relocating, raising or lowering of a structure or utility for Contractor's convenience.

1.5 RESTORATION

- A. Acceptable Standards for Restoration:
 - 1. Restore to the better of:
 - a. Original condition.
 - b. Requirements of the Contract Documents.
 - c. Current MDOT Standard Specifications for Construction.
 - d. MDOT Standard Plans.
- B. Property Corners, Government Survey Corners, and Plat Monuments:
 - 1. Protect from damage or disturbance.
 - 2. Protect discovered points until Engineer or Owner has witnessed or otherwise referenced their locations.
 - 3. Replace if disturbed or removed as a result of construction:
 - a. Arrange for replacement by a Licensed Land Surveyor.
 - b. Pay all costs.
- C. Driving Surfaces and Similar Improvements:
 - 1. Repair or replace damaged or removed surfaces as indicated on the Drawings and as specified herein.
 - 2. Adjust to temporary or final grade all new and existing castings (water valve boxes, manholes, catch basins and similar structures) for all gravel, bituminous or concrete surfacing or resurfacing.
- D. Landscaping and Miscellaneous Improvements:
 - 1. Includes, but is not limited to, topsoil, seeded areas, sodded areas, shrubs, trees, decorative plantings, fences, mailboxes, signs, guard posts and other similar items.
 - 2. Protect from damage by construction operations. In event of damage, replace damaged item with one of equivalent type and size.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 SURFACE RESTORATION

- A. Unless Otherwise specified or indicated on the Drawings, perform the following surface restorations:
1. System Descriptions:
 - a. Bituminous Base Course - Bituminous Paved Roadway:
 - 1) Subbase: 6 inches.
 - 2) Bituminous Base Course:
 - a) Collector Roadway: 6 inches.
 - b) Local Roadway: 3 inches.
 - 3) Bituminous Leveling Course:
 - a) Collector Roadway: 1-1/2 inches.
 - b) Local Roadway: 1-1/2 inches.
 - 4) Bituminous Top Course: 1-1/2 inches.
 - b. Aggregate Base Course - Bituminous Paved Roadway:
 - 1) Subbase: 8 inches.
 - 2) Aggregate Base Course:
 - a) Collector Roadway: 12 inches.
 - b) Local Roadway: 6 inches.
 - 3) Bituminous Leveling Course:
 - a) Collector Roadway: 2 inches.
 - b) Local Roadway: 1-1/2 inches.
 - 4) Bituminous Top Course: 1-1/2 inches.
 - c. Bituminous Base Course - Bituminous Shoulders, Approaches, Driveways, Alleys, Parking Areas:
 - 1) Subbase: 4 inches.
 - 2) Bituminous Base Course: 3 inches.
 - 3) Bituminous Top Course: 1-1/2 inches.
 - d. Aggregate Base Course - Bituminous Shoulders, Approaches, Driveways, Alleys, Parking Areas:
 - 1) Subbase: 4 inches.
 - 2) Aggregate Base Course: 6 inches.
 - 3) Bituminous Leveling Course: 1-1/2 inches.
 - 4) Bituminous Top Course: 1-1/2 inches.
 - e. Aggregate Surface Roadways, Shoulders, Approaches, Driveways, Alleys, Parking Areas:
 - 1) Subbase: 4 inches.
 - 2) Aggregate Base Course: 6 inches.
 - 3) Aggregate Surface Course: 2 inches.
 - f. Bituminous Walkways and Bicycle Paths:
 - 1) Subbase: 4 inches.
 - 2) Aggregate Base Course: 4 inches.
 - 3) Bituminous Top Course: 2 inches.
 - g. Concrete Roadway Pavements:
 - 1) Subbase: 6 inches.
 - 2) Concrete Pavement: 8 inches.
 - 3) Reinforcement: 4 x 4 - W6.5 x W6.5.
 - h. Concrete Shoulders and Driveways:
 - 1) Subbase: 6 inches.
 - 2) Concrete Pavement: 6 inches.
 - 3) Reinforcement: 6 x 6 - W6.5 x W6.5.
 - i. Concrete Curb and Gutter:
 - 1) Same subbase and aggregate base as adjacent roadway.
 - 2) Match existing curb and gutter profile.

- j. Concrete Sidewalks:
 - 1) Subbase: 4 inches.
 - 2) Concrete: 4 inches.
 - 3) Reinforcing: 6 x 6 - W1.4 x W1.4.
- k. Turf Establishment - Sodding and Seeding:
 - 1) Topsoil Thickness: 4 inches.
 - 2) Perform final grading, watering, backfilling of washouts, and related work.
 - 3) Sodded and seeded areas shall be weed free and established prior to acceptance.
- l. Landscaping:
 - 1) New, transplanted, relocated, and removed and replanted items shall be healthy and growing prior to acceptance.
 - 2) Watering is Contractor's responsibility and an incidental expense.
- 2. Material requirements for surface restoration unless specified otherwise:
 - a. Subbase: MDOT Granular Material Class II.
 - b. Aggregate Base Course: MDOT Dense Graded Aggregate 22A.
 - c. Aggregate Surface Course: MDOT Dense Graded Aggregate 22A.
 - d. Bituminous Base Course: MDOT 700-20C.
 - e. Bituminous Leveling Course: MDOT 1300L-20AA.
 - f. Bituminous Top Course: MDOT 1300T-20AA.
 - g. Concrete Roadway Pavement: MDOT 35P.
 - h. Concrete Driveways and Approaches: MDOT 35P.
 - i. Concrete Curb and Gutter: MDOT 35S.
 - j. Concrete Sidewalk: MDOT 35P.
 - k. Turf Materials: MDOT 6.53.
 - l. Landscaping Materials: MDOT 6.50.
 - m. All Other Materials: Incidental and as required by MDOT.
- 3. Construction Standards for Surface Restoration: Comply with MDOT construction requirements unless otherwise specified or indicated on the Drawings.

3.2 PAYMENT FOR UTILITIES AND ASSOCIATED STRUCTURES

- A. Payment for Work on Utilities and Associated Structures:
 - 1. If Work is by Utility Company: Pay costs.
 - 2. If Work is by Contractor: Perform work in accordance with the requirements of utility company or authority having jurisdiction.

END OF SECTION 01 18 13

SECTION 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. This is achieved by beginning in the design phase and documenting design intent (Owner's project requirements) and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, test, adjust, balance, and performance testing.
- B. Commissioning during the construction phase is intended to achieve the following specific objectives:
1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
 2. Verify and document proper performance of equipment and systems.
- C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
- D. Abbreviations: The following are common abbreviations used in the Commissioning Specifications and in the Commissioning Plan.

| | | | |
|---------|--------------------------------|---------|---|
| A/E | Architect and Design Engineers | EC | Electrical Contractor |
| CC | Construction Checklist | ECS Sub | Environmental Control System Contractor |
| CM | Construction Manager | FT | Functional Test |
| Cx | Commissioning | MC | Mechanical Contractor |
| Cx Plan | Commissioning Plan | RC | Refrigeration Contractor |
| CxA | Commissioning Authority | Subs | Subcontractors |

1.2 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning authority (CxA), the Owner, the Owner's Facility Manager, the designated commissioning representative of the Construction Management firm (CM), the architect and design engineers of record (A/E) (particularly the mechanical engineer), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Environmental Control System Contractor (ECS Sub), and other installing subcontractors or suppliers of equipment.
- B. Scheduling. The CxA will work with the CM according to established protocols to schedule the commissioning activities. The CxA will provide sufficient notice to the CM for scheduling commissioning activities. The CM will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner.
- C. The CxA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The Cx Plan provides a format for this schedule. As construction progresses more detailed schedules are developed by the CxA.

1.3 COMMISSIONING PROCESS

- A. Commissioning Plan.
1. The Cx Plan provides guidance in the execution of the commissioning process.
 2. The Cx Plan provided as part of the bid documents is binding on the Contractor.
 3. Just after the commissioning scoping meeting (see below) the CxA will update the plan, which is then considered the "final" plan, though it will continue to evolve and expand as the project progresses.

- B. Commissioning Process. The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.
1. Commissioning during construction begins with a scoping meeting conducted by the CxA where the commissioning process is reviewed with the commissioning team members.
 2. Additional meetings will be required throughout construction, scheduled by the CxA in conjunction with the CM with necessary parties attending, to plan, coordinate, and schedule future activities and resolve problems.
 3. The CxA, through the CM, provides the ECS Sub, MC and EC Subs checklists to be filled out during construction.
 - a. Typically, there will be checklists for each system. The MC, EC, and ECS Sub fill out the construction checklists under their own direction and in accordance with the schedule requirements which are stated in the Cx Plan.
 - b. Completed construction checklists are submitted to the CM who provides copies to the CxA.
 - c. The CxA reviews the checklists and reports to the CM any deficiencies which need correction.
 4. Equipment Start-up:
 - a. Scheduled by the CM.
 - b. Start-up documentation will include the commissioning start-up checklist and the manufacturer's detailed start-up documentation referred to above.
 - c. The CxA documents that the start-up was completed according to the approved plans. This includes the CxA witnessing start-up of selected equipment.
 5. Development of Functional Tests:
 - a. The CxA develops specific equipment and system functional test procedures.
 - b. The commissioning team members review the procedures and provide comment.
 - c. CxA incorporates comments as appropriate.
 6. Review of Specified Test Reports (e.g., flushing and cleaning, etc.):
 - a. For all systems/equipment being commissioned, the CM provides the CxA a schedule for submission of test results required by the specifications.
 - b. The CxA reviews test results and provides comment to the CM.
 - c. Items of non-compliance are corrected at the Contractor's expense and revised test results submitted for review.
 7. Execution of Functional Tests:
 - a. Scheduled by the CM for the individual systems and equipment to be tested.
 - b. Shall not be executed until full CCs for associated systems/equipment are approved by the CxA.
 - c. The functional test procedures are executed by the MC, EC Subs, and ECS Sub as appropriate, under the direction of the CxA.
 - d. Items of non-compliance in material, installation, and operation are corrected and the system retested at the Contractor's expense.
 - e. The CxA may terminate testing and require retesting when non-compliant issues are found.
 8. Deferred testing is conducted, as specified or required.
 9. Except for deferred testing, functional testing is completed before Substantial Completion.

1.4 RELATED WORK

- A. Additional commissioning requirements will be given in the following specification sections. All of the following sections apply to the Work of this section.
1. HVAC Systems Commissioning
 2. Electrical Systems Commissioning

1.5 RESPONSIBILITIES

- A. All Parties:
1. Follow the Cx Plan.
 2. Attend commissioning scoping meeting and additional meetings, as necessary.
 3. Properly schedule, log, and discharge commissioning activities and responsibilities throughout this project.

- B. A/E:
1. Construction and Acceptance Phase:
 - a. Attend the commissioning scoping meeting and selected commissioning team meetings.
 - b. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual review, etc., as contracted.
 - c. Provide latest documentation of design narrative documentation requested by the CxA.
 - d. Respond to RFIs generated through the commissioning process.
 - e. Review and approve the O&M manuals.
 - f. Assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings, or equipment documents are not sufficient for writing detailed testing procedures.
 - g. Provide "Owner's Project Requirements" documentation prior to 95% completion stage of the construction documents:
 - 1) Owner's Project Requirements: Describe the functional requirements of the building and how it is expected to be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information as appropriate.
- C. Commissioning Authority (CxA): The primary role of the CxA is to develop and coordinate the execution of a testing plan, observe and document installation and performance – that systems are installed and functioning in accordance with the documented design intent and in accordance with the Contract Documents. The Contractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied by the CxA. The CxA shall not assume responsibility for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving and resolution of non-conformance and deficiencies, but ultimately that responsibility resides with the Owner and the A/E.
1. Construction and Acceptance Phase:
 - a. Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules, and technical expertise.
 - b. Provide commissioning activities information including a Cx Plan to the CM to coordinate the commissioning work and ensure that commissioning activities are scheduled into the master construction schedule prepared by the CM.
 - c. Plan and conduct a commissioning scoping meeting and other commissioning meetings.
 - d. Revise, as necessary, the Cx Plan following the scoping meeting.
 - e. Request and review additional information required to perform commissioning tasks, including contractor start-up and checkout procedures.
 - f. Before start-up, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
 - g. Write and distribute construction checklists.
 - h. Perform site visits to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
 - i. Review all or part of the HVAC piping test and flushing procedures, sufficient to be confident that proper procedures were followed. Notify Owner's project manager of any deficiencies in results or procedures.
 - j. Witness all or part of any ductwork leakage testing procedures, sufficient to be confident that proper procedures were followed. Notify Owner's project manager of any deficiencies in results or procedures.
 - k. Approve construction checklist completion by reviewing construction checklist reports and by selected site observation and spot checking.
 - l. Approve systems start-up by reviewing start-up reports and by selected site observation.
 - m. Review the checkout plan for the controls portion of the Environmental Control System.
 - n. Oversee sufficient controls system checkout.

- o. With necessary assistance and review from installing contractors, write the functional test procedures for equipment and systems. This may include energy management control system trending, stand-alone data logger monitoring or manual functional testing.
 - p. Analyze any functional performance trend logs and monitoring data to verify performance.
 - q. Coordinate, witness and approve manual functional tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
 - 1) The CxA shall have the authority to reschedule functional testing in part or in entirety at the time of scheduled testing if any of the following conditions exist: Required participants are not present, required pre-test data is not complete, incomplete installation as required for testing, numerous test steps fail, indication of improper maintenance, inadequate instrumentation, existence of conditions unsafe to people or equipment.
 - r. Maintain an Issues Log and a separate testing record. Provide the CM with written reports with recommended actions.
 - s. Sign-off (final approval) on individual commissioning tests as completed and passing. Recommend completion of the commissioning process to the Owner.
 - t. Compile and maintain a commissioning record.
 - u. Provide a final commissioning report (as described in this Section).
- D. Construction Manager – Owner's Representative (CM):
- 1. Construction and Acceptance Phase:
 - a. Assign a single person to manage the commissioning activities on behalf of the CM and serve as a single point of contact and communication for the CM in all commissioning activities.
 - b. Include commissioning activities in the master construction schedule and ensure MC, EC Subs and ECS Sub participation and responsiveness in the commissioning process. CM is responsible for dividing the Work among Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work: Refer to the commissioning plan for more detailed information.
 - 1) Mechanical Subcontractor:
 - a) Provide related work as specified herein to support the mechanical systems Cx work being performed by CxA.
 - b) Perform system start-up functions including, but not necessarily limited to: Operate all motorized equipment to confirm proper function.
 - c) Correct all mechanical system deficiencies identified by CxA.
 - 2) Environmental Control System (ECS) subcontractor:
 - a) Provide related work as specified herein to support the mechanical systems Cx work being performed by CxA.
 - b) In a timely manner, review and comment on feasibility of functional test (FT) steps as developed by CxA.
 - c) Operate all temperature control devices to support Cx work:
 - (1) Operate each and every phase of the ECS separately, or in conjunction one with the other for a sufficient period of time to demonstrate the ability of the system to meet performance requirements in accordance with the true intent and purpose of these Specifications.
 - (2) ECS Subcontractor is responsible for verifying and demonstrating that each Sequence of Operation is being performed and design conditions stably maintained under operating conditions through the use of FT procedures. ECS Subcontractor shall work with CxA in development of FT procedures.
 - d) Correct all ECS system deficiencies identified by CxA.
 - e) Provide CxA on-line controls system access and training for CxA to view real-time system operation and obtain historical trend data of controls points.
 - (1) Training and access shall be provided prior to functional testing.
 - (2) CxA access shall be maintained for the duration of the warranty period (typically one year following date of substantial completion)
 - c. Enforce on-time submittal of commissioning documentation by ECS Sub, MC, EC, and TAB Sub, especially, but not limited to, construction checklists and systems manual documentation.
 - d. Attend commissioning scoping meeting and other commissioning team meetings to facilitate the commissioning process.
 - e. Perform the normal review of Contractor submittals.

- f. Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.
 - g. When necessary, observe and witness construction checklist completion, start-up and functional testing of selected equipment.
 - h. Furnish CxA a copy of specification-required construction test reports, e.g., pipe leak tests.
 - i. Review commissioning progress and Issues Logs.
 - j. Coordinate the resolution of deficiencies identified in all phases of commissioning.
 - k. Coordinate the training of Owner personnel.
 - l. Include the cost of commissioning in the total contract price.
 - m. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.
 - n. Prepare O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
 - 2. Warranty Period:
 - a. Ensure that Subs execute seasonal or deferred function performance testing, witnessed by the CxA, according to the Specifications.
 - b. Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
 - E. Owner:
 - 1. Construction and Acceptance Phase:
 - a. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and training sessions.
 - b. Provide final approval for the completion of the commissioning work.
 - F. Equipment Suppliers:
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 - 2. Assist in equipment testing as specified in agreements with Subs.
 - 3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone data logging equipment that may be used by the CxA.
 - 4. Through the contractors to whom they supply products, analyze specified products and verify that the designer has specified the newest most updated equipment.
 - 5. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
 - 6. Review test procedures for equipment installed by factory representatives.
- 1.6 SYSTEMS TO BE COMMISSIONED
- A. Refer to Individual Commissioning Specification Sections:
 - 1. Division 23 Section "Commissioning of HVAC."
 - 2. Division 26 Section "Commissioning of Electrical Systems."

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform start-up and initial checkout and required functional testing shall be provided by the contractor for the equipment being tested.
- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment shall be included in the base bid price, and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Portable data logging equipment and associated software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified in the Owner's project requirements document. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have resolution of 0.1 degrees F and calibration within 6 months of use to an accuracy of ± 0.5 degrees F. Pressure sensors shall have been calibrated within 6 months of use to an accuracy of $\pm 3.0\%$ of the value being measured (not full range of device)
1. All calibration shall be to NIST traceable standards. (National Institute of Standards and Technology – www.nist.gov, 301.975.6478).
 2. All equipment shall be calibrated according to the manufacturer's recommended intervals and immediately after being dropped or damaged.
 3. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

Not Used

END OF SECTION 01 91 13

SECTION 05 50 00 – METAL FABRICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing, fabrication and erection of metal fabrications, including the major items listed below:
 - 1. Boiler Vent Stack support frame.
 - 2. Expansion bolts for the general trades.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the pertinent provisions of the following:
 - 1. ASTM Standard Specifications:
 - a. A36 - Structural Steel.
 - b. A325 - Structural Bolts, Heat-Treated, 120/105 ksi Minimum Tensile Strength.
 - c. A563 - Carbon and Alloy Steel Nuts.
 - d. A992 - Steel for Structural Shapes for Use in Building Framing.
 - e. E488 - Strength of Anchors in Concrete and Masonry Elements.
 - f. E1512 - Testing Bond Performance of Adhesive-Bonded Anchors.
 - g. F436 - Hardened Steel Washers.
 - h. F1554 - Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength.
 - 2. AISC publications:
 - a. Code of Standard Practice for Steel Buildings and Bridges (excluding Section 4.2.1).
 - b. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
 - c. Detailing for Steel Construction.
 - d. Manual of Steel Construction.
 - e. Specification for Structural Joints Using ASTM A325 or A490 Bolts.
 - 3. AWS publications:
 - a. ANSI/AWS A5.1 - Carbon Steel Electrodes for Shielded Arc Welding.
 - b. ANSI/AWS A5.4 - Stainless Steel Electrodes for Shielded Arc Welding.
 - c. ANSI/AWS D1.1 - Structural Welding Code - Steel.
 - 4. ASME - American Society of Mechanical Engineers:
 - a. ANSI/ASME B18.2.1 - Heavy Hex Structural and Askew Head Bolts.
 - b. ANSI/ASME B18.6.1 - Wood Screws.
 - c. ANSI/ASME B18.6.3 - Slotted and Recessed Head Machine Screws.
 - d. ANSI/ASME B18.21.1 - Lock Washers.
 - e. ANSI/ASME B18.22.1 - Plain Washers.
 - 5. Federal Specifications:
 - a. FS FF-B-588C(1) - Bolt, Toggle, and Expansion Sleeve, Screw.
 - 6. Occupational Safety and Health Act.
 - 7. NAAMM - National Association of Architectural Metal Manufacturers.

1.4 CONNECTION DESIGN REQUIREMENTS

- A. Fabricator:
 - 1. Responsible for the structural design of all connections except those specifically indicated on the Drawings as Engineer designed.
 - 2. Coordinate type of connection (bolted or welded) with steel erector.
- B. General Types of Connections: Indicated on Drawings.

- C. Design of Connections:
 - 1. Equal to standard framing connections in accordance with AISC - Manual of Steel Construction.
 - 2. Minimum Load Connection:
 - a. Two 3/4-inch diameter bolts, or
 - b. Welds with a total capacity of 6,000 pounds.
 - 3. Connections: Bolted bearing type unless indicated otherwise on Drawings.

1.5 SUBMITTALS

- A. Shop Drawings: For all members to be furnished to include:
 - 1. Detail Drawings of Members and Connections:
 - a. In accordance with AISC - Detailing for Steel Construction.
 - b. Size and number of bolts.
 - c. Dimensions.
 - d. Connection angles and plates.
 - 2. Erection Drawings: Locate and identify members.
 - 3. Welding: In accordance with AWS welding symbols.
 - 4. Type of paint.
- B. Provide setting drawings, templates and directions for the installation of anchor bolts and other devices.

1.6 QUALITY ASSURANCE

- A. Fabrication and Erection Personnel Qualifications:
 - 1. Trained and experienced in the type of work being performed.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
- B. Welders, Welding Operators and Tackers Qualifications:
 - 1. Qualified by tests in accordance with Section 5 of AWS D1.1.
 - 2. Qualification Papers:
 - a. Given by an independent testing laboratory.
 - b. Dated no earlier than 6 months prior to beginning of Project.
 - 3. Engineer, at Engineer's discretion, may accept evidence of previous qualifications.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration, damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Reject damaged, deteriorated or distorted material and immediately remove from the Site. Replace rejected materials with new material at no additional cost to Owner.
- D. Embedded Items:
 - 1. Includes anchor rods and other anchorage devices which are to be embedded in cast-in-place concrete or masonry.
 - 2. Delivered on the Project Site in time to be installed before the start of cast-in-place concrete or masonry operations.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Materials shall be new, top quality of their respective kinds, standard sizes and fabricated in a shop whose principal business is manufacturing the items specified in this Section.

- B. Yield Stress and Type of Steel:
 - 1. For Wide Flange Shapes: ASTM A992 with yield stress of 50,000 psi.
 - 2. For S Shapes, Channels, Angles, Bars, Plates and Rods: ASTM A36 with yield stress of 36,000 psi.

2.2 METAL FABRICATIONS

- A. Fasteners:
 - 1. Bolts: Use carbon or alloy steel, ASTM A325 3/4-inch diameter bolts or larger as required by connection design.
 - 2. Nuts: Carbon Steel: ASTM A563.
 - 3. Washers:
 - a. Hardened Steel Washers: ASTM F436.
 - b. Plain Washers: ASME B18.22.1, round, carbon steel.
 - c. Lock Washers: ASME B18.21.1, helical, spring type, carbon steel.
 - 4. Lag Bolts: ASME B18.2.1, square or hex head type.
 - 5. Toggle Bolts: Tumble wing type in accordance with FS FF-B-588.
 - 6. Machine Screws: ASME B18.6.3.
 - 7. Wood Screws: ASME B18.6.1.
- B. Anchors:
 - 1. Expansion:
 - a. Wedge style anchor.
 - b. Capable of withstanding 6 times the imposed load capacity in unit masonry and 4 times the imposed load capacity in concrete when tested in accordance with ASTM E488.
 - c. Hilti Kwik Bolt 3; Powers Rawl Power Stud; or equal.
 - d. Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
 - e. Dry Areas: Mild steel, galvanized in accordance with ASTM B633.
 - 2. Injectable Adhesive Anchors:
 - a. In Concrete or Solid Grouted Masonry: Hilti HIT HY-150; Powers Rawl Power Fast; or equal.
 - b. In Hollow Brick or Hollow Masonry: Hilti HIT HY-20; Powers Rawl Power Fast with screen tubes; or equal.
 - c. Anchored Material: Carbon steel or stainless steel rods, or reinforcing bars as indicated on the Drawings.
 - d. Bonding Strength: Tested in accordance with ASTM E1512.
 - 3. Sleeve Anchors:
 - a. Hilti Sleeve Anchor; Powers Rawl Lok Bolt; or equal.
 - b. Hex, acorn, round, or flat head as situation requires or as indicated on the Drawings.
 - c. Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
 - d. Dry Areas: Mild steel, galvanized in accordance with ASTM B633.
- C. Anchor Rods: ASTM F1554, Grade 36.
- D. Other Materials: All other materials not specifically described but required for a complete and proper installation of the work of this Section, shall be new, first quality of their respective kinds, and as selected by Contractor subject to approval of Engineer.

2.3 FABRICATION

- A. General:
 - 1. Workmanship: Install items square and level, accurately fitted and free from distortion and defects.
 - 2. Temporary Bracing:
 - a. Make provision for erection stresses by temporary bracing.
 - b. Keep work in alignment.
 - 3. Welding:
 - a. Steel welding shall be performed in accordance with AISC Specification Section J and AWS D1.1.
 - b. Filler metal requirements for steel welding processes shall be as shown in Table 4.1 of AWS D1.1 and AWS A5.1.
 - c. Filler metal requirements for aluminum welding processes shall be in accordance with AWS A5.3.
 - d. Stainless steel welding shall be performed in accordance with AWS D1.6.

- e. Filler metal requirements for stainless steel welding processes shall be in accordance with AWS A5.4.
- f. Welding shall be continuous along entire area of contact.
- 4. Painting: Prime paint metal fabrications using fabricator's standard prime paint.
- 5. Straightness tolerances, additive to deflection, shall not exceed $\pm 1/16$ -inch to 10 feet.
- 6. All cope, miter, and butt caps on exposed surfaces shall be made to the closest possible tolerances consistent with metal shop equipment and practice in order to provide a pleasing appearance.
- 7. Fastening shall be concealed where practicable. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water. Provide holes and connections for the work of other trades.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Workmanship: Install items square and level, accurately fitted and free from distortion and defects.
- B. Erection – Bracing:
 - 1. Provide all shoring, bracing and accessories required for complete erection.
 - 2. Safety and adequacy of bracing and temporary bracing are the responsibility of the Contractor.
- C. Coordination: Supply to appropriate trades items to be cast into concrete or embedded in masonry, complete with necessary setting templates.
- D. Tightening:
 - 1. Tighten bolts snug-tight as defined by AISC, unless otherwise noted on the Drawings.
 - 2. Tighten bolts in slotted holes using the AISC Turn-of-the-Nut Method, unless indicated otherwise on the Drawings.
 - 3. Where specifically indicated on the Drawings, finger-tighten nuts in connections where movement must be permitted, and tighten a jam nut over finger-tightened nut, or peen bolt threads, to prevent nut backoff.
- E. Touch-up:
 - 1. After erection is complete, touch up all shop priming coats damaged during transportation and erection.
 - 2. Prime all field welds, bolt heads, nuts and abrasions using the priming paint specified for shop priming.
 - 3. Touch up all damaged galvanized areas with a zinc rich paint meeting ASTM D520 and ASTM A780.
- F. Welding: Field welding shall be performed to the same standards and requirements of shop welding.
- G. Protection: Where required, provide approved protection against galvanic action between contacts of dissimilar metal or situations that will cause deterioration of metal in contact or associated in any way.

3.2 CLEANING

- A. Prior to acceptance of the work of this Section, thoroughly clean all installed materials and related.

END OF SECTION 05 50 00

SECTION 23 01 00 – OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Division 01 Specification Sections, apply to this Section.
- B. Refer to individual Division 23 sections for additional equipment specific Operations and Maintenance Manual requirements.

1.2 SUMMARY

- A. This Section includes preparing and furnishing an operating and maintenance manual for mechanical equipment.

1.3 DESCRIPTION

- A. Compile an Operating and Maintenance Manual:
 - 1. For all building mechanical systems and major equipment items.
 - 2. Including, but not necessarily limited to:
 - a. Installing company's name, address, telephone number and name of job supervisor.
 - b. Maintenance and operating booklets (as supplied by the equipment Manufacturer) for each item or representative type item installed.
 - c. Valve tag schedule.
 - d. A complete set of Shop Drawings.
 - e. Control drawings.
 - f. Equipment information forms for each equipment piece.
 - 3. Each equipment information form include all applicable items of the following:
 - a. Type of unit.
 - b. Manufacturer's name.
 - c. Equipment service area.
 - d. Motor Information:
 - 1) HP.
 - 2) Voltage.
 - 3) Phase.
 - e. Lubrication Information:
 - 1) Recommended service interval.
 - 2) Lubricant application points.
 - 3) Recommended lubricant type.
 - f. Recommended cleaning procedures and intervals.
- B. Prepare Information Packets:
 - 1. Attach to each major piece of equipment in a string tie envelope labeled with the equipment's designation in large print.
 - 2. Information Required:
 - a. A copy of the equipment information form as defined above.
 - b. A control written operation sequence.
 - c. A maintenance checklist form with equipment identification information and listing all relevant maintenance procedures in a column format to accommodate date entries.

1.4 SUBMITTALS

- A. Three copies of Operating and Maintenance Manual.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION 23 01 00

SECTION 23 05 00 – GENERAL HVAC PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes specifying the general requirements for execution of that portion of the Work defined in Division 23 of these Specifications and as indicated on the Drawings:
 - 1. Major items include, but are not necessarily limited to:
 - a. Cutting and patching.
 - b. Concrete foundations and support steel.
 - c. Piping, fittings and valves.
 - d. Piping and equipment insulation.
 - e. Temperature and pressure gages.
 - f. HVAC equipment.
 - g. Control systems.
 - h. Demolition of existing mechanical work.
 - i. Labor, materials, equipment, tools, supervision and start-up services.
 - j. Mechanical systems testing, adjusting and balancing.
 - k. Mechanical systems commissioning.
 - l. Instructions to Owner regarding operation.
 - m. Incidental and related items necessary to a complete and functionally operational installation of the Work.
- B. Division of Work: In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the Work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the Work:
 - 1. General Contractor:
 - a. Install access doors.
 - b. Provide concrete isolation and housekeeping pads for mechanical equipment.
 - c. Provide access doors in walls for access to mechanical equipment.
 - 2. Mechanical Subcontractor:
 - a. Bear financial responsibility for cutting and patching of walls, ceilings, and floors for Division 23 Work.
 - b. Furnish location, size and quantity of openings to Contractor before construction of new walls, ceilings, and floors.
 - c. Furnish size and locations of concrete equipment isolation and housekeeping pads as required for this Work and as indicated on the Drawings to Contractor before slabs are poured.
 - d. Furnish size and location of access doors required for this work as indicated on the Drawings to Contractor.
 - e. Provide miscellaneous structural steel required in connection with support of the Work of Division 23.
 - f. Perform final cleaning of mechanical systems and equipment.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of Division 23 shall comply with the following:
 - 1. ANSI: A13.1 - Standard for the Identification of Piping Systems.
 - 2. ASME - American Society of Mechanical Engineers:
 - a. B31.1 - Power Piping.
 - b. B31.9 - Building Services Piping.

- c. Boiler and Pressure Vessel Code:
 - 1) Section I.
 - 2) Section II.
 - 3) Section IV.
 - 4) Section VIII.
- 3. ASTM: A325 - Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
- 4. International:
 - a. Currently enforced edition of Building Code including Michigan amendments.
 - b. Currently enforced edition of Mechanical Code including Michigan amendments.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

- A. Construction details, components, accessories, sizes and model numbers indicated on the Drawings or in these specifications are used to indicate minimum levels of quality and coordination requirements.
- B. Design and layout, including clearances and service access, are based on Manufacturer, model and components as scheduled or otherwise indicated on the Drawings. Other listed approved Manufacturer's components and equipment are acceptable provided the following conditions are satisfied:
 - 1. Meet minimum requirements listed in specifications or on Drawings, be compatible with facility and intended use, and meet requirements for a functional system.
 - 2. Present to Engineer documentation verifying that all the above conditions are satisfied at least 10 days prior to bid receipt date.
 - 3. Meet all sound criteria as listed. Additional sound attenuation materials may be used if required.
 - 4. Coordinate and pay for all changes resulting from the use of alternate equipment and components:
 - a. Coordinate and pay for all resulting work in other trades, including redesign efforts.
 - b. Make all duct and piping system changes required in utilizing alternate equipment. Changes must reflect building conditions, ceiling spaces, chase sizes, structure locations.
 - c. Obtain Engineer's prior approval for all changes to layout, clearances, components and service access proposed.
- C. Drawings:
 - 1. Are diagrammatic and indicate general arrangement of systems and work included.
 - 2. Do not necessarily indicate every required valve, fitting, trap, thermometer, gage, elbow, mounting support and access panel.
 - 3. Shall not be scaled for measurement or installation location.
 - 4. Shall not serve as Shop Drawings.
- D. Schedules and model numbers shall not be used to:
 - 1. Serve as final, definitive quantity requirements. Contractor shall make own count as indicated on Drawings.
 - 2. Determine proper type or model with arrangement, mounting and accessories applicable.
- E. Coordinate installation work of Division 23 with work of other trades to provide a complete and functional system

1.5 SUBMITTALS

- A. System Start-up Schedules:
 - 1. Submit 2 weeks prior to earliest proposed date.
 - 2. List time and date for the following for each system:
 - a. Start-up.
 - b. Demonstration.
- B. Completion Reports:
 - 1. Submit within 1 week after each system demonstration.
 - 2. List time, date and persons present for the following for each system:
 - a. Start-up.
 - b. Demonstration.

3. Include Manufacturer's representative's report indicating:
 - a. Approval of installation.
 - b. Satisfactory start-up.
 - c. Functioning correctly.
4. Indicate that demonstration and instructions were satisfactorily completed.

1.6 PRODUCT UNLOADING AND HANDLING

- A. Unload equipment and materials required for completion of the Work.
- B. Handle and store equipment and materials carefully to prevent damage. Method of rigging and handling shall be subject to the approval of an authorized representative of the equipment Manufacturer whose equipment is being handled.

1.7 TROUBLESHOOTING

- A. By Contractor: If, during the start-up or warranty period, mechanical systems operational problems occur for which the root cause is not readily apparent, Contractor shall promptly, through a Subcontractor or other resource designated by Subcontractor, provide diagnostic and investigative services to determine the cause or causes.
- B. By Engineer:
 1. At Contractor's request, Engineer will provide the services necessary to determine the cause or causes of the operational problems.
 2. Under the provisions of the General Conditions, Engineer will also provide these services if Contractor fails to respond satisfactorily to operational problems within a reasonable time after written notice from Engineer.
 3. If while working at Contractor's request or under the provisions of the General Conditions, Engineer determines that the problems are due to failure of the Work to comply with the requirements of the Contract Documents, Owner will compensate Engineer for additional services and deduct the amount paid from payment or payments to Contractor.

1.8 MAINTENANCE

- A. Special Tools: Where special tools are required for operation, furnish these to Owner.
- B. Loose and Detachable Parts:
 1. Retain loose and small detachable parts of the apparatus and equipment furnished until the completion of the Work.
 2. Turn over these parts to Owner.
- C. Permanent Heating Equipment:
 1. Notify Engineer when installed and proposed to be used to heat building interior.
 2. Prior to using, provide adequate means to keep internal duct and acoustic liner surface clean and in a like-new condition.
- D. Construction Strainers:
 1. Remove after flushing and cleaning and prior to commencement of TAB.
 2. Attach removed construction strainer to piping where removed as proof of removal.

PART 2 - PRODUCTS

2.1 FABRICATIONS

- A. Miscellaneous Structural Steel:
 1. Comply with the requirements of Division 05 Section "Metal Fabrications," where applicable.
 2. Structural steel work shall be done in accordance with the AISC Specification for Design, Fabrication and Erection of Structural Steel for Buildings, except that allowable stresses shall be reduced 25%.

3. Where required, high strength structural steel bolting conforming to ASTM Specification A325 and assembled to AISC "Specifications for Assembly of Structural Joints. Using High Strength Steel Bolts" or welding shall be used in place of rivets.
4. Connections shall be properly designed for the type of connection and the loads to be carried, and shall be subject to Engineer's or Owner's approval.
5. Welding shall be done by operators who have been previously qualified by tests as prescribed in the American Welding Society "Standard Qualification Procedure" to perform the type of work required.
6. Welding techniques shall conform to the American Welding Society "Code for Arc and Gas Welding in Building Construction", Section 4, Workmanship.
7. Finished members shall be true to line and free from twist, bends and open joints.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Character of Work: Installation shall be executed in a workmanlike manner and shall present a neat mechanical appearance when completed.
- B. Laying Out of Work:
 1. Layout piping, equipment and components in accordance with the Contract Documents and the Manufacturer's recommended practice, including provision of adequate space for maintenance. Review layout with Engineer prior to installation.
 2. Check drawings of other trades to verify spaces in which work will be installed. Maintain maximum head room and space conditions at all points. Where head room or space conditions appear inadequate, notify Engineer before proceeding with installation.
 3. If directed by Engineer, Contractor shall make reasonable modifications in the layout as required to permit proper execution of the Work and to prevent conflict with work of other trades.
 4. Work shall be installed so as to be ready for operation, maintenance and repair. Minor deviations from Drawings may be made to accomplish this. Changes shall not be made without approval of Engineer.

3.2 PIPE FITTINGS

- A. Provide insulating couplings or unions where dissimilar materials are joined.
- B. Provide unions at valves and at equipment for making repairs.

3.3 PAINTING

- A. Paint exposed, non-insulated piping.
 1. Surface Preparation:
 - a. Comply with Steel Structures Paint Council Specifications.
 - b. Remove rust and mill scale using power tool.
 - c. Clean using power tool and water wash to remove weld spatter, flux and alkali contaminants.
 2. Application:
 - a. One coat water base inhibitive metal primer.
 - b. Two coats water base glass acrylic epoxy.
 - 1) 275 square feet per gallon minimum.
 - 2) Color: As selected by Owner.
- B. Provide labels as specified below. Comply with OSHA "Safety Color Code for Marking Physical Hazards" and ANSI A13.1 for pipe labels and colors.
- C. Valves, Fittings, and Supports:
 1. Paint valves and fittings the same base color as the pipe they adjoin.
 2. Paint floor stands the same base color as the pipe they adjoin.

3.4 CODING AND TAGGING

- A. Piping:
 - 1. Applied to new piping after installation, insulation, and final painting.
 - 2. Conform to Owner's existing standards or conventions.
 - 3. Markings:
 - a. Painted on, 1-inch high black letters.
 - b. Color coded band, conforming to ANSI A13.1.
 - c. Directional arrow.
 - 4. Place markers at 20-foot centers with at least 1 in each room and at each change in direction.
 - 5. Plastic coated "Set Mark-Snap-Around" pipe markers manufactured by Seton Name Plate Corp., New Haven, Connecticut; or approved equal, may be used in lieu of painted markers and bands.
- B. Valves:
 - 1. Provide brass or minimum 1/16-inch thick laminated plastic tags indicating assigned valve number on valves.
 - 2. Furnish schedule(s) of tagged valves with number, location and purpose of each valve.
 - 3. Place a copy of each schedule in the Maintenance Instructions.
- C. Equipment:
 - 1. Provide for:
 - a. Each boiler.
 - b. Labeled with its tag name/number as given on the Drawings.
 - c. Use 2-inch high stenciled painted lettering.
 - 2. Similarly label control components associated with the above named equipment items.

3.5 START-UP

- A. Coordinate the start-up, testing and shutdown of the new equipment and systems involved.
- B. Operating personnel, fuel, water, power and other utilities necessary for equipment start-up, will be furnished by Owner. Instructions shall be provided to the operators by the equipment vendor's personnel.
- C. Inspection:
 - 1. Verify that Project conditions comply with requirements.
 - 2. Verify that status of Work meets requirements for starting of systems.
- D. Preparation:
 - 1. Coordinate sequence for start-up of various systems.
 - 2. Notify Engineer 7 days prior to start-up of each system.
 - 3. Have at hand during entire start-up process:
 - a. Contract Documents.
 - b. Shop Drawings.
 - c. Product data.
 - d. Operation and maintenance data.
 - 4. Verify that each piece of equipment has been checked for:
 - a. Proper lubrication.
 - b. Drive rotation.
 - c. Control sequence.
 - d. Other conditions which may cause damage.
 - 5. Verify control systems are fully operational in automatic mode.
 - 6. Verify that tests, meter readings and specific electrical characteristics agree with those specified by electrical equipment Manufacturer.
 - 7. Bearings:
 - a. Inspect for cleanliness, clean and remove foreign materials.
 - b. Verify alignment.
 - c. Replace defective bearings and those which run rough or are noisy.
 - d. Grease as necessary and in accordance with Manufacturer's recommendations.
 - 8. Drives: Clean and remove foreign materials before starting operation.

9. Motors:
 - a. Check each motor for amperage comparison to nameplate value.
 - b. Correct conditions which produce excessive current flow and which exist due to equipment malfunction.
 - c. 3-phase Motors: Measure voltage imbalance between legs. Notify Engineer if imbalance exceeds 2%.
10. Flanges:
 - a. Tighten flanges after system has been placed in operation.
 - b. Replace flange gaskets which show any sign of leakage after tightening.
11. Screwed Joints:
 - a. Inspect screwed joints for leakage.
 - b. Promptly remake each joint which appears to be faulty; do not wait for rust to form.
 - c. Clean threads on both parts, apply compound and remake joints.
12. Cleaning:
 - a. After system has been placed in operation, clean strainers, dirt pockets, orifices, valve seats and headers in fluid systems, to ensure being free of foreign materials.
 - b. Open steam traps and air vents; remove operating elements. Clean thoroughly, replace internal parts, and put back into operation.
 - c. Remove rust, scale and foreign materials from equipment and renew defaced surfaces.
13. Draft Gages: Set and calibrate draft gages of air filters and other equipment.
14. Control Circuits: Check each electrical control circuit to ensure that operation complies with Specifications and requirements to provide desired performance.

3.6 ADJUSTING

- A. Adjust and align equipment for smooth operation:
 1. Plumb true and with parts in proper position and alignment.
 2. Rotating parts shall turn freely and in the correct direction.
 3. Flexible couplings shall be checked for alignment subject to Owner's approval.
 4. Follow Manufacturer's instructions.
- B. The work of installation shall be executed in conformity with the best practice, so as to contribute to efficiency of operation, minimum noise or vibration, minimum maintenance, accessibility and sightlines.

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services:
 1. Provide when required by individual Section.
 2. Provide the following services except where indicated otherwise in individual Sections:
 - a. Inspect, check and approve system installation.
 - b. Supervise system start-up.
 - c. Provide written report indicating that system:
 - 1) Has been properly installed and lubricated.
 - 2) Is in accurate alignment.
 - 3) Is free from undue stress imposed by connecting lines or anchor bolts.
 - 4) Has been satisfactorily operated under full load conditions.
 - d. Demonstrate operation of system to Owner's personnel.
 - e. Instruct Owner's personnel on operation and maintenance of system.
- B. Performance Test:
 1. Test the entire Work, including all of its individual systems for 2 weeks before final payment will be made.
 2. Every phase of heating shall be operated separately, or in conjunction one with the other to demonstrate to Engineer the ability of the plant to meet capacity and performance requirements while maintaining design condition, in accordance with the true intent and purpose of these Specifications.
 3. Make final tests in the presence of Owner and Engineer.
 4. If a part of the Work or equipment does not meet Specifications:
 - a. Correct the situation.
 - b. Obtain approval of Engineer before final payment is made.
 5. Provide the personnel and bear costs for correcting malfunctions.

6. Owner will provide operating personnel and utilities.
7. Systems balancing shall be completed prior to performance testing.

C. Preparation:

1. Verify That System:
 - a. Has been inspected and put in service.
 - b. Is fully operational.
2. Operation and Maintenance Manuals:
 - a. Completed.
 - b. Sufficient copies available for use in demonstrations and instructions.
3. System balancing shall have been completed prior to these performance tests.

D. Demonstration and Instructions:

1. Demonstration Of and Instruction On Operation and Maintenance of System:
 - a. To Owner's personnel.
 - b. Two weeks prior to final inspection.
2. Equipment Requiring Seasonal Operation: Demonstration within 12 months.
3. Instruction:
 - a. Operation and maintenance manual as basis.
 - b. Review contents of manual in detail.
 - c. Explain aspects of operation and maintenance.
4. Demonstrate:
 - a. Start-up.
 - b. Operation.
 - c. Control.
 - d. Adjustment.
 - e. Troubleshooting.
 - f. Servicing.
 - g. Maintenance.
 - h. Shutdown.

3.8 CLEANING AND FINISHING

- A. Entire installation shall be free from surface oil and grease before work will be considered for final payment.
- B. After tests have been made and the system pronounced tight:
 1. Clean piping and equipment.
 2. Lubricate bearings.
- C. Final cleaning includes but is not limited to the following:
 1. Equipment with Factory Finishes:
 - a. Wash factory-finished equipment with mild soap and water and leave in first-class condition, entirely free of stains or streaks.
 - b. Do not use abrasive materials.
 - c. Touch up scratches or other violations of the factory finish paint with matching paint from the equipment Manufacturer.

END OF SECTION 23 05 00

SECTION 23 05 03 – STEEL PIPE AND FITTINGS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of steel pipe and fittings.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ANSI Standards:
 - a. B16.3 - Malleable Iron Threaded Fittings.
 - b. B16.4 - Cast-Iron Threaded Fittings, Class 125 and 250.
 - c. B16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloys and Other Special Alloys.
 - d. B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.
 - e. B16.11 - Forged Steel Fittings, Socket Welding and Threaded.
 - f. B16.21 - Nonmetallic Flat Gasket for Pipe Flanges.
 - g. B18.2.1 - Square and Hex Bolts and Screws, Inch Series.
 - h. B18.2.2 - Square and Hex Nuts.
 - i. B31.1 - Power Piping.
 - j. B31.9 - Building Services Piping.
 - 2. American Society of Mechanical Engineers (ASME) publications:
 - a. Boiler and Pressure Vessel Code.
 - b. Power Boiler Code.
 - c. Heating Boiler Code.
 - 3. ASTM Standards:
 - a. A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
 - b. A105 - Forgings, Carbon Steel, for Piping Components.
 - c. A106 - Seamless Carbon Steel Pipe for High-Temperature Service.
 - d. A126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - e. A181 - Forgings, Carbon Steel for General Purpose Piping.
 - f. A182 - Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves for High Temperature Service.
 - g. A193 - Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
 - h. A194 - Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.
 - i. A197 - Cupola Malleable Iron.
 - j. A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
 - k. A269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - l. A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile.
 - m. A312 - Seamless and Welded Austenitic Stainless Steel Pipe.
 - n. A395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

1.4 SUBMITTALS

- A. Submit Manufacturer's Literature for Steel Pipe and Fittings: Include Manufacturer name, Manufacturer location, dimensions, and details of construction and installation.
- B. Manufacturer's Literature: For couplings and gasketing material.

1.5 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
- B. Labeling: Piping materials shall bear the label, stamp or other marking of all specified standards and testing compliance.
- C. Testing of Steel Piping: In accordance with Division 23 Section "Testing and Cleaning of HVAC Systems."

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General:
 - 1. Except as herein specified or as indicated on the Drawings, all materials shall be in accordance with the Piping Systems Schedule in Part 3 of the appropriate applicable specification section.
 - 2. Pipe 6'-0" and longer shall be permanently marked with the following information:
 - a. Manufacturer's name.
 - b. Pressure rating.
 - c. Size.
 - 3. Unless indicated otherwise in application sections of these specifications, all pipe joints shall be welded for pipe sizes 2-1/2 inches and larger.
- B. Black Steel Pipe:
 - 1. Black steel pipe shall be welded or seamless carbon steel, as specified for the type of service.
 - 2. Welded black steel pipe shall meet the requirements of ASTM A53 or A106, and shall be Type F continuous-weld furnace butt-welding (CW), or Type E electric resistance welded (ERW) Grade B.
 - 3. Seamless black steel pipe shall meet the requirements of ASTM A53 or A106, Type S seamless, Grade A or B.
- C. Stainless Steel Tubing and Fittings:
 - 1. Distribution Piping: ASTM A269, Type 315 stainless steel:
 - a. 1/2-inch OD; minimum 0.035-inch wall thickness.
 - b. 3/4-inch OD; minimum 0.049-inch wall thickness.
 - 2. Fittings and Manifolds:
 - a. Welded.
 - b. Compression, Swagelok; or equal.
 - 3. Minimum 15,000 psi rating.

2.2 FITTINGS

- A. Unions:
 - 1. Pipe Sizes 2 Inches and Smaller:
 - a. Forged steel with ground joint.
 - b. Properly fitted for design temperature and pressure.
 - c. 2000 pound rated equal to Crane No. 250H or 251H.
 - d. 3000 pound rated equal to Crane No. 252H.
 - 2. Pipe Sizes 2-1/2 Inches and Greater: Use companion flanges where unions are required.
- B. Tapped Bosses:
 - 1. Permitted in pipes and fittings.
 - 2. 1-1/2-inch maximum hole size.
 - 3. Boss Construction:
 - a. Weld material built up to a thickness 50% greater than required threads.
 - b. Forged bosses as approved by Engineer.

- c. 300 pound rated half couplings welded to pipe permitted for instrument connections 3/4-inch or smaller.
- C. Screwed Fittings:
 - 1. Class 300 iron in accordance with ANSI B16.4.
 - 2. Nodular or ductile iron in accordance with ASTM A395.
 - 3. Forged steel in accordance with ASTM A181.
 - 4. Schedule 80 fittings shall be used with Schedule 80 pipe.
- D. Welding Fittings:
 - 1. Meet ASTM A 234 symbol WPA or WPB.
 - 2. The A or B grade shall conform to the grade of pipe used with the fittings.
 - 3. Dimensional standards shall conform to ANSI B16.9.
 - 4. Schedule 80 fittings shall be used with Schedule 80 pipe.
- E. Flanges:
 - 1. General:
 - a. Welding neck or slip-on type with raised face.
 - b. Conforming to ANSI B16.5.
 - c. Class 150 and 300 conforming to ASTM A181, Grade I.
 - d. Class 600 and 900 conforming to ASTM A105, Grade II.
 - 2. Use threaded or socket weld type for piping smaller than 2-1/2 inches.
 - 3. Use flat face steel flanges when matching cast iron companion flanges.
- F. Flange Gaskets:
 - 1. Nonasbestos compressed material conforming to ANSI B16.21 and suitable for 600 degrees F service.
 - 2. Ring type, 1/16-inch thickness.
 - 3. Spiral wound stainless steel for service over 300 psi.
 - 4. Use full face gaskets with flat face flanges.
- G. Bolting Material:
 - 1. General:
 - a. Carbon steel, square-head bolts and Grade 2H hex nuts.
 - b. Bolt length shall be sufficient to extend completely through nut with maximum 3/8-inch projection.
 - c. Dimensions conforming to ANSI B18.2 (bolts) and ASTM A194 (nuts).
 - 2. Bolts:
 - a. For service below 250 psig/450 degrees F, use Grade B conforming to ASTM A307.
 - b. For service at or above 250 psig/450 degrees F, use Grade B7 conforming to ASTM A193.
- H. Socket Welding Fittings: All forged steel socket-welding fittings shall conform to ANSI Standard B16.11 ASTM A105 Gr. II, equal to Crane 3,000-pound forged fittings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. During Freezing Weather:
 - 1. Protect all materials in such a manner that no harm can be done to:
 - a. Installations already made.
 - b. Materials and equipment on the Site.
 - 2. Furnish all necessary protection for such installations and equipment as may be required.

3.2 ERECTION

- A. General:
 - 1. All Piping: Follow approved paths as indicated on the Drawings.
 - 2. Connect to existing lines where required, or to equipment in an approved manner.
 - 3. Locate Pipes, Valves and Equipment to Provide:

- a. Access for maintenance.
 - b. Minimum obstruction of passageways and working space.
 4. Normally, all pipe runs shall be plumb, parallel with the building and level, except for drain slope.
 5. Be responsible for establishing and maintaining drain slope of piping in order to ensure drainage.
 6. Expansion of Piping:
 - a. All pipe connections shall provide freedom of movement of the piping during expansion and contraction without springing of piping or injury to building steel or structure.
 - b. Any damage to building steel or structure as a result of work installed by Contractor shall be repaired at Contractor's expense.
 7. As Piping Material is Erected:
 - a. Thoroughly clean the inside of all piping.
 - b. Remove foreign material such as scale, sand, weld spatter, particles and cutting chips.
 8. Provide caps or plugs in all openings at the end of each day's work and as otherwise directed for the protection of the piping. Particular attention must be given to avoid the possibility of any foreign material entering the pipes.
 9. Flanges shall be made on pipe so that the gasket surface forms an angle of 90 degrees with the pipe axis. Screwed flanges shall be made on until the pipe projects through the flanges and then the flanges must be refaced.
- B. Sleeves and Holes:
 1. Contractor shall be responsible for cutting required holes and openings in floors, walls and other structures, except as noted on the Drawings. Sleeves will be placed by Contractor in all such openings, and no holes shall be cut without Owner's approval. Sleeves shall be in accordance with the standard details included in the Drawings.
 2. All holes in floors, walls, roofs, etc., where pipe lines or other materials have been removed or installed, shall be neatly and properly filled with concrete, brick or other material in accordance with the general character of the construction at the location.
- C. Unions and Eccentric Fittings:
 1. Unions shall be provided at each screwed valve and where their use will facilitate dismantling of the piping and as required or directed in special cases.
 2. Eccentric fittings or eccentric reducing couplings shall be provided in all cases where air or water pockets would otherwise occur in the main due to the reduction in pipe size.
 3. Eccentric fittings shall keep the pipes flush on the bottom for steam and condensate piping.
- D. Pipe Joints:
 1. Pipe connections at all valves shall be mechanically joined unless otherwise indicated on the Drawings or reviewed by Owner or Engineer.
 2. Mitered joints shall not be permitted.
 3. In general, black steel 2-1/2-inch and larger shall be welded except that a flange or union shall be provided at all valves and at equipment.
 4. The connections to welded 2-1/2-inch and larger pipe shall be made with a welding tee or Weld-o-let of butt, socket or threaded type as required. Scarf welding of side connections shall not be permitted.
 5. Only welding ells shall be used for changing pipe directions of welded pipe lines.

3.3 WELDING

- A. All Pipe Welding:
 1. Where welding is called for, it shall be of the fusion process and shall consist of welding by means of either the oxyacetylene or electric arc process.
 2. The pipe assembly at orifice and flow nozzle locations shall be left unassembled until inspected and approved by Owner or Engineer.
 3. All welding shall conform to the ASME Boiler and Pressure Vessel Code or the ANSI Code for Pressure Piping. All welders shall be qualified in accordance with ASME Standard Qualifications for Welding Procedures, Welders and Welding Operators, or Section 9 of the ASME Boiler and Pressure Vessel Code for the class of piping being welded. Submit welding qualifications for all welders on the Project when requested by Engineer.
 4. No welding to building work shall be allowed without approval of Engineer.
 5. Black steel piping may be welded with chill rings in lieu of that specified.

6. Mitered turns will not be allowed. Turns shall be made with welded type fittings.
7. Branch take-offs with manufactured formed nipples will be permitted, if not restricted by code, and where nipple size is at least two pipe sizes smaller than the main size. Formed nipples shall be Bonney Forge "Weldolets", "Threadolets", "Sockolets."

B. Welding for Steam 15 psig or Above:

1. Backing rings furnished by Contractor shall be used where called for or required except that backing rings may be omitted if the welder is qualified for welding without them. The inside circumference of welds at orifice flanges shall be ground smooth and uniform.
2. Each welded joint shall have the welder's initials, last 2 numbers of the year and a symbol indicating whether backing rings were used or not. All marks shall be located where easily accessible according to the following order or preference: Top center, north, east, south and west.
3. Submit a certified copy of "Record of Pipefitter Welder Performance Qualification Test" of any of their employees who will be doing welding on this project.
4. Shop welded pipe assemblies shall have all welds plainly stamped by the welding operator for inspection by the Engineer before installation.
5. Examine all piping welds by physical method. Include the cost of examining 5 welds to be selected at the discretion of Owner, by approved graphic method similar to gamma ray process, or other appropriate NDT method as approved by Owner.
6. All welds on all services in the direct buried conduit shall be 100% X-ray inspected and passed.
7. The radiographic examination shall be by technicians of a reputable company regularly engaged in this type of work and skilled in the use of interpretation of results of this type of examination.
8. The process shall provide visual proof at the Site and such proof on photographs with reports which shall become the property of the Owner and will be included in the final Contract Documents.
9. The report on the interpretation of the radiographic examination shall state whether or not the quality of the welding is suitable for the service for which the piping was designed.
10. Welds examined by the above process shall be identified by a number and service symbol and shall be stamped into pipe adjacent to weld at the time of examination
11. Failure to pass this test shall be cause for the rejection of the weld and authority to examine two additional welds that have been done by the same welder, for each case. Rejected welds shall be repaired at the Contractor's expense by an approved method and proven satisfactory by radiographic examination. Inspection and approval verification of repaired welds shall be at Contractor's expense.
12. If 3 welds prove unsatisfactory by the radiographic examination, all welds shall be X-rayed. Any welds proved unacceptable shall be repaired and X-rayed again at no additional expense to the Owner.
13. Owner may examine welds at structural supports and pipe attachment assemblies at their discretion.

3.4 ADJUSTING AND CLEANING

- A. Clean and test piping in accordance with Division 23 Section "Testing and Cleaning of HVAC Systems."

END OF SECTION 23 05 03

SECTION 23 05 19 – METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all temperature and pressure gages. Unless otherwise specified, gages shall be as described in this Specification.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASME Standard:
 - a. B40.1 - Gages - Pressure, Indicating Dial Type - Elastic Element.
 - b. B40.30 - 1990 - Thermometers.

1.4 SUBMITTALS

- A. Manufacturer's Literature: For all gages and thermometers. Include name of Manufacturer, model, dimensions, and scale range.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Ametek.
- B. Ashcroft.
- C. H.O. Trerice.
- D. Trend Instruments.
- E. Weiss.

2.2 EQUIPMENT

- A. Dial Thermometer:
 - 1. Bimetal type with adjustable dial face.
 - 2. 5-inch diameter dial.
 - 3. 6-inch nominal stem length.
 - 4. Union lock nut.
 - 5. Zero adjustment.
 - 6. Hermetic seal.
 - 7. Equal to H.O. Trerice B85600 Series.
- B. Industrial Thermometer:
 - 1. Aluminum case, acrylic face, adjustable angle, blue spirit filled tubing.
 - 2. 9-inch scale.
 - 3. 3-1/2-inch nominal stem length. (6-inch for pipe sizes 6 inches and over).
 - 4. Equal to H.O. Trerice BX91 Series.

- C. Pressure Gage:
 - 1. Bourdon tube type or bourdon coil type with direct coupled pointer, liquid filled.
 - 2. 4-1/2-inch minimum diameter.
 - 3. Accuracy of +1% of scale range.
 - 4. Equal to H.O. Trerice 450 Series.
 - 5. Liquid fill must be compatible with temperatures in measured fluid.

2.3 ACCESSORIES

- A. Thermowell:
 - 1. Provide for all thermometers.
 - 2. 304 stainless steel.
 - 3. Equal to H.O. Trerice Cat. No. 138-0015.3 (138.0016.2 for pipe 6 inches and over).
- B. Coil Siphon:
 - 1. Provide for all steam system installations.
 - 2. Brass.
 - 3. Equal to H.O. Trerice Series 885.
- C. Needle Valve:
 - 1. Provide for all pressure gages.
 - 2. Equal to H.O. Trerice Series 735.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all thermometers and pressure gages in conformance with:
 - 1. The Drawings.
 - 2. These Specifications.
 - 3. Manufacturer's recommendations.
- B. Support all pressure gages and remote-reading thermometers:
 - 1. With 12-gage formed steel bracket.
 - 2. Secured to structure or equipment.

3.2 APPLICATION

- A. Select all dial ranges such that normal operating temperature/pressure measured at point of installation is near mid-range.

END OF SECTION 23 05 19

SECTION 23 05 23 – GENERAL DUTY VALVES FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all valves.

1.3 REFERENCES

- A. Except as specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
 - 2. Flanged: Valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).
 - 3. Threaded: Valve ends complying with ANSI B2.1.
 - 4. Solder-Joint: Valve ends complying with ANSI B16.18.
 - 5. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).
 - 6. Welded Ends: Valve ends complying with ASME/ANSI B16.5.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

- A. General:
 - 1. This Section is provided as a guide in the application and specification of specific valves intended for use in this Project. This Section does not instruct where to install these valves unless specifically noted. Refer to other specific Mechanical Specification Sections and Drawing details for instruction for location and use.
 - 2. As indicated on the Drawings.
 - 3. As called out in the Piping Systems Schedules.
- B. Valves not specifically indicated on the Drawings:
 - 1. Size and class of valve and pipe schedule to agree with line in which installed.
 - 2. All valves 2-1/2-inch and larger shall be flanged unless noted otherwise.
- C. Valves shall have Manufacturer's name, trademark and working pressure rating cast into the valve body.

1.5 SUBMITTALS

- A. Shop Drawings for all valves.
- B. Manufacturer's Literature: For All Valves:
 - 1. Manufacturer's name.
 - 2. Details of construction.
 - 3. Performance characteristics.
 - 4. Pressure and temperature ratings.
 - 5. Close-off pressure.

1.6 QUALITY ASSURANCE

- A. Made in USA:
 - 1. Unless specifically noted otherwise, all valves shall comply with the Federal Trade Commission Made in USA standard.
 - 2. Supplier shall furnish documentation of USA content if requested by Engineer.
- B. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the material and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Valves shall be manufactured by one Manufacturer for each type of valve. Where valve Manufacturers are not specifically indicated, they shall be one of the following:
 - 1. Gate, Ball, Globe, Standard Butterfly, and Check Valves:
 - a. Nibco.
 - b. Kennedy.
 - c. Crane.
 - d. Milwaukee.
 - e. Keystone.
 - f. Stockham.
 - g. Bonney Forge.
 - h. Mueller Steam Specialties.
 - i. Neles-Jamesbury.
 - j. DeZurik.
 - k. Apollo.
 - l. Vogt.
 - m. Walworth.
 - n. Powell.
 - 2. Spring-Loaded Check Valves (2CK1W):
 - a. Advance Valve Co., "Durabla SCV."
 - b. CheckAll Valve Manufacturing Co.

2.2 GENERAL

- A. Materials - Bronze Valves:
 - 1. All brass alloys used in valves shall contain no more than 15% zinc.
 - 2. Alloys must comply with ASTM B61, B62 or B584.
- B. Additional Materials: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by the Manufacturer for installation requirements.
 - 1. Provide extended stem handles and necks with a minimum clearance of 1-1/2-inch on insulated service.
 - 2. All valves used for throttling/balancing shall have adjustable memory stops.
 - 3. Pressure ratings are at service indicated by application as specified according to the individual valve specifications.
 - 4. Sizes: Same size as upstream pipe, unless otherwise indicated.
 - 5. Neck extensions and right angle drives where indicated and where required for access to the operator.
- C. Operators: Provide the following special operator features:
 - 1. Handwheels, fastened to valve stem, for valves other than quarter turn.
 - 2. Lever handles, on quarter-turn valves 3-inch and smaller, except for plug valves. Provide plug valves with square heads. For valves greater than 3-inch, provide gear operator with handwheel.
 - 3. Provide bevel gear operators with chain-wheels for all valves installed 6 feet or higher above finished floor. Extend chains to an elevation of 5 feet above finished floor.

4. Provide rotary manual actuators with high ratio (80 to 1 minimum), disc positions and open and closed position stops on all butterfly valves. Actuators shall be designed for valve installation with the stem in a horizontal orientation to prevent debris from accumulating in the bearings.

D. Valve Identification Systems Description:

1. A system has been established which identifies the specific valves for each piping system as indicated on the Drawings. The specific valve specification is linked by the service number as depicted in the "Valve Index" listed in this Section.
2. Valves may be identified on the Drawings by symbol. Size is indicated by the upstream size.
3. Valves are specified in this Section according to the "Valve Index". In general, the following is a description of the format:
 - a. The first symbol, consisting of one or more numerals, indicates the valve group pressure and temperature specification that applies to this valve.
 - b. The second symbol, consisting of one or more letters, indicates the type of valve in accordance with the following listing:
 - 1) GB = Globe Valve.
 - 2) BF = Standard Butterfly Valve.
 - 3) BL = Ball Valve.
 - 4) CK = Check Valve.
 - 5) SCK = Silent Check Valve.
 - 6) GT = Gate Valve.
 - c. The third symbol consists a numeral which indicates the size group.
 - d. The fourth symbol, consisting of a letter, indicates the type of connection to the valve as follows:
 - 1) F = Flanged Ends.
 - 2) S = Screwed Ends.
 - 3) W = Weld Ends, Butt, or Socket.
 - e. For example: For a 10-inch CHW shutoff valve, refer to 1BF2F which indicates a valve of Valve Group 1, Butterfly Type, and with flanged ends.
4. There may be some instances where it is desirable to substitute an item, such as a valve or gasket at a particular location, in place of the one specified in the groups listed in the Index. In that event, the item will be clearly indicated and specified on the Drawings, and such an indication is to take precedence over the item specified in the valve group specifications. All other terms of that group specification are to be observed.

2.3 VALVE GROUP 1

A. Gate Valves:

1. Symbol: 1GT1S – 2 Inches and Smaller:
 - a. Class 125 valves used for piping 2 inch in size and smaller shall all bronze, bolted bonnet, rising stem, solid wedge, bronze mounted, screwed ends, and designed for 125 psig.
2. Symbol: 1GT2F - 2-1/2 Inches and Larger:
 - a. Class 150 steel gate valve, flanged ends, bolted flanged bonnet, outside screw and yoke, rising stem, flexible or solid wedge disc, renewable seat rings and disc.
 - b. Materials shall be: Body and bonnet, ASTM A216, Grade WCB or A105; carbon steel body; stem, disc face and seat rings 13% chromium stainless steel or a combination of 13% chromium stainless steel and nickel-copper, stellite or a combination of stellite and 13% chromium stainless steel as recommended by its manufacturer for steam service.
 - c. Face to face dimension shall conform to ANSI B16.10. Flanges shall be faced and drilled to ANSI B16.5.
 - d. Working pressure and temperature ratings shall comply with ANSI B16.34 (Standard Class).
 - e. Where indicated on the Drawings, provide an enclosed gear operator.

B. Globe Valves:

1. Symbol: 1GB1S - 2-inch and smaller :
 - a. 125 pounds wsp, bronze body, rising stem, screwed bonnet, Teflon disc, and renewable seat.
 - b. Solder joint end 2-inch and smaller:300 CWP, bronze body, rising stem, screwed bonnet, Teflon disc, and renewable seat.

2. Symbol: 1GB2F – 2-1/2 inch and larger:
 - a. Flanged end, Class 125, iron body.
 - b. Bronze trim, OS&Y bonnet, teflon disc, renewable seat, and spring-loaded packing.
- C. Ball Valves:
 1. Symbol: 1BL1S - 2 Inches and Smaller:
 - a. Ball valves used in connection with piping 2 inches in size and smaller shall have screwed or sweat ends, 2 piece bronze body, standard port with stainless steel ball and a like stem. VA rated for 150 pound SWP and 600 WOG. Seats and seals shall be reinforced virgin teflon for standard duty cycle.
 - b. Provide with locking handle for chilled water valves in tunnel.
 2. Symbol: 1BL2F – 2-1/2 Inches and Larger:
 - a. Ball valves used in connection with piping 2-1/2 inches in size and larger shall have flanged ends, 2 piece bronze body, standard port with stainless steel ball and a like stem. VA rated for 150 pound SWP and 600 WOG. Seats and seals shall be reinforced virgin teflon for standard duty cycle.
 - b. Provide with locking handle for chilled water valves in tunnel.
- D. Standard Duty Butterfly Valves:
 1. Symbol: 1BF2F – 2-1/2 Inches and Larger:
 - a. Iron body rated for 175 psig and 250 degrees F, bubble-tight shutoff.
 - b. Lug body for use with ANSI flanges. Wafer style is not acceptable, except where specifically approved.
 - c. Stainless steel disk, 416 stainless steel shaft, EPDM seat.
 - d. Provide neck extended 2 inches beyond flange diameter.
 - e. Bevel gear operator.
- E. Plug Valves:
 1. Plug valves shall be nonlubricated eccentric plug type rated for 175 CWP with semi-steel body neoprene coated plug and epoxy coated seat; equal to DeZurik PEC or Homestead Series 300. Furnish with compatible wrench. All valves used for throttling/balancing to have adjustable memory stop.
 2. Plug valves (gas cock) for natural gas shutoff applications shall be lubricated type equal to Homestead Figure 611 or 612 or Rockwell Figure 114 or 115.
- F. Check Valves:
 1. Symbol: 1CK1S - 2 Inches and Smaller:
 - a. Class 150 horizontal swing check valve, cast bronze body and cover, screwed ends, bronze seat and disc, screwed cover, integral seat, body and cover material to conform to ASTM B61 or B62.
 - b. Provide valves capable of being reground while the valve remains in the line.
 - c. Provide Class 150 valves meeting the above specifications, with threaded end connections, where system pressure requires or where Class 125 valves are not available.
 - d. The valve shall conform to MSS SP-80.
 2. Symbol: 1CK2F - 2-1/2 Inches and Larger:
 - a. MSS SP-71; Class 125 cast iron body and bolted cap conforming to ASTM A126, Class B.
 - b. Horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends.
 - c. Face to face dimension shall conform to ANSI B16.10. Flange shall be faced and drilled to ANSI B16.5.
 - d. Working pressure and temperature ratings shall comply with ANSI B16.34 (Standard Class).
- G. Silent Check Valve:
 1. Symbol: 1SCK1S – 2 Inches and Smaller:
 - a. Install silent check valves in all pump discharge.
 - b. Piping less than 2-inch: 300 pounds, bronze body, renewable bronze disc screwed or sweat ends, bronze trim.
 - c. Mueller Steam Specialties, #303 BP; or equal.
 2. Symbol: 1SCK2F – 2-1/2 Inches and Larger:
 - a. 125 pounds, globe type, iron body, bronze trim, renewable seat and disc, SS springs.
 - b. Mueller #105-AP; or equal.

2.4 VALVE GROUP 2

A. Gate Valves:

1. Symbol: 2GT1W - 2 Inches and Smaller:
 - a. Class 800 forged steel, shall be bolted bonnet, rising stem, solid wedge.
 - b. Socket or butt welded, ASTM A105 carbon steel to match Schedule 40 and 80 pipe end.
 - c. Stems shall be 13% chromed stainless with steel handwheel; equal to Vogt SW13111.
2. Symbol: 2GT2W- 2-1/2 Inches and Larger:
 - a. Class 150, shall be manufactured in accordance with API600, OS&Y.
 - b. Bolted bonnet, welded ends, carbon steel body, solid wedge flexible disc, Type XU trimmed, and non-asbestos packing and gaskets. Body and bonnet shall conform to ASTM A216.
 - c. Valves shall be equal to Crane No. 47-1/2.

B. Globe Valves:

1. Symbol: 2GB1S - 2-inch and smaller :
 - a. Threaded end, Class 300, bronze body, rising stem, union bonnet, renewable SS seats, SS disc,
2. Symbol: 10GB2F – 2-1/2 inch and larger:
 - a. Flanged end, Class 250, cast steel or ductile iron body, OS&Y bonnet.
 - b. Stainless steel trim, teflon disc, renewable seat, and spring-loaded packing.

C. Silent Check Valves:

1. Symbol: 2SCK1W - 2 Inches and Smaller:
 - a. Spring loaded disc with metal seats.
 - b. All stainless steel and rated for 150 psig at 500 degrees F steam service conditions.
 - c. Shall have socket weld ends.
 - d. For condensate pump discharge, use Durabula, Model SCV.

D. Swing Check Valves:

1. Symbol: 2CK1S – 2 inch and Smaller:
 - a. Class 200, bronze, threaded, Y-pattern, screwed cap, regrindable disc, conforming to ASTM B61.
2. Symbol: 2CK2F - 2-1/2 Inches and Larger:
 - a. Class 150 steel horizontal swing check valve, flanged ends, bolted flanged cover and renewable seat ring.
 - b. Body material shall conform to stainless steel ASTM A182 Grade F316L or CF8M.
 - c. Disc or disc seating face and the seat ring shall be 13% chromium stainless steel.
 - d. Face to face dimension shall conform to ANSI B16.10.
 - e. Flange shall be faced and drilled to ANSI B16.5.
 - f. Working pressure and temperature ratings shall comply with ANSI B16.34 (Standard Class).

E. Ball Valves:

1. Symbol: 2BL1W - 2 Inches and Smaller:
 - a. Rated for steam service at 150 psig, 500 degrees F conditions; 2 piece construction, with carbon steel body, regular port, 316 stainless steel ball and stem, replaceable seats and seals rated for temperature, blowout proof stem, vinyl covered steel handle, socket weld ends and extended stem for insulated piping.

2.5 FLANGE CONNECTIONS

- A. Flange Gaskets: Refer to Division 23 Sections "Steam and Condensate Piping" for requirements for flange gaskets used on steam valves.
- B. Flange Bolts: Refer to Division 23 Sections "Steam and Condensate Piping" for requirements for flange bolts used on steam valves.

2.6 DRAIN VALVES

- A. Furnish at each low point 3/4-inch gate or ball valves as specified above.
- B. Install nipple with cap at valve outlet.

PART 3 - EXECUTION

3.1 VALVE SCHEDULE

- A. Unless otherwise noted on drawings or in specific application sections of this specification, the valve groups described in Part 2 of this specification shall be applied for each service type as follows:
 - 1. Valve Group 1:
 - a. Hydronic service not exceeding 125 psig or 250 degrees F.
 - b. Saturated steam less than 15 psig.
 - c. Steam condensate not exceeding 15 psig and 250 degrees F after the trap.
 - 2. Valve Group 2:
 - a. Steam up to 125 psig and 500 degrees F.
 - b. Steam condensate from steam service up to 125 psig and 500 degrees F prior to the trap.
 - c. Pumped steam condensate not exceeding 125 psig and 250 degrees F.

3.2 INSTALLATION

- A. Install valves in conformance with:
 - 1. The Shop Drawings reviewed by Engineer.
 - 2. The Manufacturer's recommendations.
- B. Install Valves:
 - 1. At all branch piping connection to mains.
 - 2. At all connections to equipment.
 - 3. As required for complete control or isolation of any piece of equipment or service to branch lines.
 - 4. In accessible locations.
 - 5. Equal in flow area to connecting piping, unless otherwise indicated.
- C. No valve shall be installed with its stem below the horizontal.
- D. Furnish chain operated hand wheels, including rust-proof chain and chain guide for inaccessible overhead valves.
- E. Install flanged valves at equipment in a manner which allows equipment side of valve to be opened up without draining piping system.

END OF SECTION 23 05 23

SECTION 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all pipe hanging and support systems.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASME - American Society of Mechanical Engineers:
 - a. B31.1 - Power Piping.
 - b. B31.9 - Building Services Piping.
 - c. B31.8 - Gas Transmission and Distribution Piping Systems.
 - 2. MSS - Manufacturers Standardization Society:
 - a. SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.
 - b. SP-69 - Pipe Hangers and Supports - Selection and Application - 1996.
 - c. SP-90 - Guidelines on Terminology for Pipe Hangers and Supports.

1.4 DEFINITIONS

- A. Pipe Restraint: Pipe supporting element which is designed to limit or direct pipe movement due to internal static pressure, gravitational forces, frictional forces from hangers, rollers, and guides, and forces from expansion compensation devices:
 - 1. Pipe restraints are not designed to restrain pipe movement caused by thermal expansion, shock or surge.
- B. Pipe Guide: A pipe restraint designed to direct pipe movement along a single axis.
- C. Pipe Anchor: A pipe restraint designed to provide a static point about which pipe movement normally occurs, by limiting the longitudinal and axial movement at that point.
- D. Other Terms: As defined in MSS SP-90.

1.5 DESIGN AND PERFORMANCE REQUIREMENTS

- A. Unless otherwise indicated on Drawings or in these Specifications, this Contractor shall be responsible to design and provide all pipe hangers, supports, restraints, braces, framing, etc., as required to comply with all applicable building codes, ASME B31 and MSS SP-69.
- B. Comply with the requirements of ASME B31.8 for pipe hangers and support of natural gas piping systems.

1.6 SUBMITTALS

- A. Manufacturer's Literature: For structural steel attachment devices, hangers and rollers. Include name of Manufacturer; model number and MSS Type, if applicable; and piping systems to be used with.

- B. Delegated-Design Submittal
 - 1. Structural calculations for anchorage systems, sealed by the Professional Engineer responsible for the design.
 - 2. Clearly indicating design criteria and loadings used.
 - 3. For each hanger and support device.
 - a. Include design calculations and details for selecting hangers and supports complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation
- C. Submit Shop Drawings for all engineered hanger, restraints and support assemblies.
 - 1. For Metal Framing Pipe Supports: Include locations, dimensions, lengths, Manufacturer, material, cross-section number or type, finish, pipe sizes, and pipe locations.
- D. Upon request by Engineer, submit calculations for all engineered hanger, restraints and support assemblies.
 - 1. Calculations: For metal framing pipe supports upon request by Engineer. Include support locations, pipe sizes, pipe weights, allowable stresses, and actual stresses.

1.7 PERFORMANCE REQUIREMENTS

- A. Design Responsibilities:
 - 1. Anchorage of outdoor piping and equipment shall be designed by Contractor or their supplier.
 - 2. Minimum Requirements:
 - a. Details, if any, indicated on the Drawings and Specifications contained herein are minimum requirements.
 - 1) Engineer has designed the structure to withstand the gravity and wind induced loadings of equipment.
 - 2) Notify Engineer of member size change requirements prior to fabrication.
 - b. Generally comply with layouts and configurations as indicated on the Drawings.
 - 3. Structural Performance:
 - a. Design shall be performed by a professional engineer.
 - b. Design shall comply with the building code plus amendments and local ordinances, if any, legally adopted for the location in which the Project is located.
 - c. Design anchorage systems capable of withstanding design loads within limits and under conditions indicated.
 - 1) The term "withstand" means that the unit will remain in place without separation of any parts from the device when subjected to the wind forces specified.
 - d. Design shall include systems that transfer gravity and wind induced loadings (including lateral, overturning and uplift effects) to the structure, including, but not limited to:
 - 1) Anchorage between piping or equipment and supports.
 - 2) Anchorage between supports and building structure.
 - 3) Spacers, blocking, straps and the like.
 - 4. Design Loads:
 - a. Dead Loads: Actual weights of materials and fixed equipment, as calculated by designer.
 - b. Wind-Restraint Loading:
 - 1) Basic Wind Speed: 120 mph.
 - 2) Determined by designer in accordance with the basic parameters indicated on the Drawings and procedures indicated in the Building Code.
 - 3) Design shall not consider shielding by adjacent structures.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. The materials of all pipe hanging and supporting elements shall be in accordance with the latest requirements of the ASME Code for Pressure Piping B31.1 and MSS Standard Practice MSS SP-58 and MSS SP-69 except as supplemented or modified by the requirements of these Specifications.

- B. The material in contact with the pipe shall be compatible with the piping material so that neither shall have a deteriorating action on the other.
- C. Special Finishes and Materials:
 - 1. All ferrous hangers and supports used in the following areas shall be hot dip galvanized unless noted otherwise:
 - a. Outside.

2.2 MANUFACTURERS

- A. Elcon.
- B. Michigan Hanger.
- C. Anvil.
- D. Bergen.
- E. Hilti.
- F. Lindapter.
- G. Thybar
- H. Pate
- I. Mirro
- J. Roof Products and Systems
- K. A.E.S.
- L. MicroMetl.

2.3 PIPE HANGERS AND SUPPORTS

- A. Horizontal Piping Hangers: Unless otherwise indicated and except as specified in piping system Specification sections, install the following types:
 - 1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN15 to DN750).
 - 2. Yoke Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 degrees F (49 to 232 degrees C) pipes, NPS 4 to NPS 16 (DN100 to DN400), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon or Alloy Steel, Double Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN15 to DN600), if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN15 to DN100), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable Swivel Split or Solid Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN20 to DN200).
 - 7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN200).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN15 to DN200).
 - 9. Adjustable Swivel Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN15 to DN50).
 - 10. Split Pipe Ring With or Without Turnbuckle Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN10 to DN200).

11. Extension Hinged or 2 Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN10 to DN80).
 12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30 (DN15 to DN750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- B. Supports and Rollers:
1. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast iron floor flange.
 2. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast iron floor flange with U-bolt to retain pipe.
 3. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion type support for pipes, NPS 2-1/2 to NPS 36 (DN65 to DN900), if vertical adjustment is required, with steel pipe base stanchion support and cast iron floor flange.
 4. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN25 to DN750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 5. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN65 to DN500), from single rod if horizontal movement caused by expansion and contraction might occur.
 6. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN50 to DN1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 7. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN50 to DN600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 8. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- C. Vertical Piping Clamps: Unless otherwise indicated and except as specified in piping system specification sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500).
 2. Carbon or Alloy Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), if longer ends are required for riser clamps.
- D. Hanger Rod Attachments: Unless otherwise indicated and except as specified in piping system specification sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 degree F (49 to 232 degree C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type II, split pipe rings.
 4. Malleable Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 degree F (49 to 232 degree C) piping installations.
- E. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification sections, install the following types:
1. Restraint Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring Cushion Roll Hangers (MSS Type 49): For equipping Type 42 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from hanger.
 6. Variable Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from base support.
 7. Variable Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25% to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical type supports and 1 trapeze member.

2.4 HANGER RODS

- A. Minimum rod diameters for rigid rod hangers shall be as shown in MSS SP-69 Table 4 (Minimum Rod Diameter for Single Rigid Rod Hangers) and as indicated in Part 3 of these Specifications.
- B. Hanger rods shall be subject to tensile loading only. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit swing.
- C. Rod material must be compatible with hanger and comply with above. Do not field cut thread on galvanized rod.
- D. Do not use perforated strap.
- E. Multiple Supports:
 1. Horizontal banks of pipe may be supported on a common base member without regard to the pipe centerline elevation.
 2. In the supporting of multiple pipe runs, provisions shall be made to keep the lines in their relative lateral positions, using clamps or clips as required. Lines subject to thermal expansion shall be free to roll axially or slide.

2.5 SADDLES AND SHIELDS

- A. All Piping:
 1. Saddle: MSS Type 39 Anvil Figure 160 -to 165.
 2. Shield: MSS Type 40 (Anvil Figure 167), provide and install in accordance with Manufacturer's shield size selection tables.
 3. The contour of the saddle shall match the radius of the pipe insulation.

2.6 ALIGNMENT GUIDES

- A. Provide where necessary to control movement:
 1. As required to maintain alignment.
 2. In accordance with Expansion Joint Manufacturer's Association recommendations.
- B. Spider Type Guides:
 1. Manufacturers:
 - a. Anvil.
 - b. Pentair - ERICO.
 - c. Keflex.
 2. Anvil Figure 255, 256; or equal.

2.7 FABRICATED STEEL SUPPORTS AND RESTRAINTS

- A. Provide as required:
 1. Steel shapes and plates.
 2. Bolts.
 3. Welds.
- B. Materials and fabrication in accordance with:
 1. AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
 2. AISC Code of Standard Practice for Steel Buildings and Bridges (except Section 4.2.1.).

- C. Design: Responsibility of Subcontractor, except as specifically indicated on Drawings.
- D. Paint all finished fabrications: Color as directed by Owner.

2.8 MANUFACTURED PIPE SUPPORT SYSTEM

- A. Acceptable Manufacturers:
 - 1. B-Line.
 - 2. Elcen.
 - 3. Super Strut, Inc.
 - 4. Unistrut Building Systems.
- B. Provide products from one Manufacturer.
- C. Channel (Standard Applications):
 - 1. Mild strip steel.
 - 2. 12 gage minimum material.
 - 3. Factory painted equal to Unistrut Perma-Green.
 - 4. Equal to Unistrut Part No. P1000.
- D. Clamps and Supports:
 - 1. Beam clamp equal to Unistrut Part No. P2785.
 - 2. Pipe strap equal to Unistrut Part No. P2558.
 - 3. Pipe roller equal to Unistrut Part No. P2474.
 - 4. All items fabricated in material equal to channel specifications.
- E. Clamp Nuts:
 - 1. Electro-galvanized stainless steel for use with stainless steel and fiberglass parts.
 - 2. Mild bar steel for standard applications.
 - 3. Class 2 American Standard threads.
 - 4. Equal to Unistrut Part No. P1012.

2.9 MANUFACTURED EQUIPMENT AND PIPING SUPPORT SYSTEM SUBJECT TO WIND OR SEISMIC LOADING

- A. Wind Restraints: Metal brackets compatible with the piping and equipment support and equipment casing, galvanized or painted to match equipment unit, used to anchor unit to the support, and designed for loads at Project site.
- B. Building Structural Steel Attachment: Provide wind restraint straps, welded strap connectors, and bolted or welded attachment methods to roof structural steel as required to meet wind uplift requirements.

2.10 BUILDING ATTACHMENTS

- A. As indicated on the Drawings or in the Specifications.
- B. Concrete Attachments:
 - 1. Provide galvanized finish for all attachments used in wet or potentially wet areas.
 - 2. Provide stainless steel bolts and nuts in wet and potentially wet areas.
 - 3. Poured Concrete:
 - a. Use cast-in-place inserts or bolted surface mounted attachments, at Contractor's option.
 - b. Expansion style anchors are not permitted on piping systems subject to vibration.

- C. Horizontal Piping:
 - 1. Steel W, I, or S shapes: MSS Type 23 clamp with retaining clip, (Anvil Fig. 88 and Fig. 89 for non-seismic and Fig. 89X for seismic applications) up to 2-inch; MSS Type 28 (Anvil Fig. 292) or MSS Type 21 (Anvil Fig. 133, 134) above 2-inch.
 - 2. Steel Channel: MSS Type 20 universal channel clamp.
 - 3. Bar Joists: Steel washer plate (Anvil Fig. 60).
 - 4. Concrete: See "B" above.
- D. Vertical Piping:
 - 1. Steel Shapes: Welded brackets as approved by Engineer.
 - 2. Concrete: See "B" above.
- E. In the absence of a Specification for a particular type of attachment, furnish attachments comparable in type and quality to that specified above for a similar situation.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. General Requirements:
 - 1. The selection of hangers and supports shall be based on the overall design concept of the system and any special requirements which may be called for in these Specifications or as indicated on the Drawings. The support systems shall provide for, and control, the free or intended movement of the system including its movement in relation to that of the connected equipment. They shall prevent excess stress resulting from the transfer of weight being introduced into the system or connected equipment.
 - 2. The selection of hangers and supports shall be made to provide the system with the degree of control that its operating characteristics require. Design hangers and supports to prevent sway and intended movement.
 - 3. The selection of hangers or supports will take into consideration the combined weight of the supported systems, including system contents.
 - 4. Select and install hangers and supports to allow controlled thermal and seismic movement of system, to permit freedom of movement between anchors, and facilitate action of expansion joints, expansion loops, expansion bends and similar units.
 - 5. The spans in MSS SP-69 Table 3 do not apply where concentrated weights, such as valves or heavy fittings, or where changes in direction of the piping occur between hangers.
 - 6. Select all hangers and supports rated for the maximum potential loading with pipe full.
 - 7. Select hangers for cold (less than 50 degrees F) piping service for installation over the insulation.
 - 8. Where significant, vertical movement of pipe occurs at the hanger location a resilient support shall be used:
 - a. Selection of resilient supports shall be based on permissible load variations and effects on adjacent equipment. Support selection for typical load variations are shown on MSS SP-69 Table 2 (Spring Support Selection). Load and movement calculations shall be made for the proper selection of spring hangers.
 - b. Vertical movement and load transfer from riser expansion to horizontal runs shall be given consideration when applying spring hangers.
 - c. Spring cushion hangers may be used where vertical movement does not exceed 1/4-inch and where formal load and movement calculations are not required.
 - d. Variable spring hangers shall be used for all other resilient support requirements except as noted in the following paragraph.
 - e. Constant support hangers shall be used on piping systems where the deviation in supporting force must be limited to 6% and which cannot be accommodated by a variable spring hanger.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification sections.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

- B. General:
 - 1. Adjust all components as required for proper operation and required pipe slope.
 - 2. Double nut all support rods at hangers.
 - 3. Location and Routing:
 - a. Install Piping as Indicated:
 - 1) On the Drawings.
 - 2) On the reviewed Shop Drawings.
 - b. Secure Engineer's approval for all pipe routing changes.
 - 4. Coordinate with other trades for placement of concrete attachments prior to concrete pouring.
 - 5. Install all items in accordance with Manufacturer's instructions.
- C. Support at Valves: Provide additional supports at all valves in piping 4-inch and larger.
- D. Vertical Risers:
 - 1. Support independently from adjacent hangers on horizontal piping.
 - 2. Vertical Threaded or Welded Steel Piping:
 - a. Support at the base of the riser and at every other floor.
 - b. Maximum allowable unsupported piping length is 12 feet.
- E. Horizontal Runs:
 - 1. General:
 - a. Provide adequate supports for the loads with a factor of safety of at least 5 (400 pounds minimum).
 - b. Provide protective shield at all hangers and rollers supporting plastic pipe and coated pipe.
 - c. Support spacing not to exceed MSS SP-69 Table 3, or the requirements for seismic restraint, whichever is more stringent.
 - d. Hanger rod diameter shall not be less than the requirements of MSS SP-69 Table 4, or the requirements for seismic restraint, whichever is more stringent.
 - 2. Rollers: All piping systems designed to accommodate thermal expansion movement shall be mounted on rollers.
 - 3. Bar Joists: Attachments to bar joists shall be made to top member and at panel points.
- F. Ductile Iron Piping: The size of hanger components shall be suitable for the O.D. of the pipe to be supported.

3.3 PIPE RESTRAINTS

- A. Provide adequate pipe restraints for all expansion or contraction of piping due to temperature change:
 - 1. Including, but not limited to, that indicated on the Drawings.
 - 2. As instructed by Owner or Engineer.
 - 3. At locations to prevent stresses from exceeding those permitted by ANSI B31 and to prevent transfer of loading and stresses to connected equipment.
 - 4. Spacing: Unless otherwise indicated, install at ends of main pipe runs, at intermediate joints in pipe runs between expansion loops and bends.

3.4 VIBRATION ELIMINATORS

- A. Provide as indicated on the Drawings and in accordance with the requirements of Division 23 Section "Sound and Vibration Control for HVAC."
- B. Install so as to cause minimum restraint to normal thermal movements.

3.5 INSULATION PROTECTION

- A. Provide Protection Saddle:
 - 1. Equal to insulation thickness.
 - 2. At each hanger.
 - 3. For all insulated piping systems where longitudinal expansion exceeds 1-inch per 100 feet.

- B. Provide insulation protection shield:
1. At each hanger for all "cold" (less than 50 degrees F) piping services.
 2. In accordance with the following table:

| Pipe Size (IPS) | Shield Gage | Length |
|------------------|-------------|--------|
| 5" and Smaller | 16 | 12" |
| 6" to 12" | 12 | 16" |
| Greater than 12" | 12 | 20" |

3. Installed as follows:
 - a. Surround lower covering.
 - b. Straddle equidistant on hanger.
 - c. Flared at both ends as required to avoid damage to pipe covering, jacket and vapor barrier.

3.6 PAINTING

- A. Touchup: Clean and touchup paint at field welds, bolted connections and abraded areas of shop paint on miscellaneous metal.
- B. Galvanized Surfaces: Clean welds, bolted connections and abraded areas. Apply galvanizing repair paint to comply with ASTM A780.

END OF SECTION 23 05 29

SECTION 23 05 31 – PENETRATIONS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of the major items listed below:
 - 1. Duct and pipe sleeves.
 - 2. Flashing and sealing of all mechanical openings through weather or waterproofed walls, roofs and floors.
 - 3. Sealing and finishing of all mechanical openings.
- B. Division of Work: In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
 - 1. General Contractor:
 - a. Locate and place all sleeved and framed openings as part of constructing the wall and floor surfaces in which the openings occur.
 - b. Provide all lintels and required stiffening members for wall and floor openings.
 - c. Cut roofing and install flashing for all required openings in proprietary roof membrane systems.
 - d. Cut all roof deck openings and provide required framing supports.
 - 2. Mechanical Subcontractor:
 - a. Advise General Contractor of quantity, location and size of all required openings.
 - b. Provide all curbs, sleeves, seals, escutcheons and related materials required for finishing, sealing and waterproofing mechanical openings. Furnish all flashing and counterflashing.
 - c. Arrange and pay for all openings required after wall, roof and floor construction is complete.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the Work of this Section shall comply with ASTM D2202 - Test Method for Slump of Sealants.

1.4 SUBMITTALS

- A. Manufacturer's Literature: For all premanufactured curbs and sealing assemblies.
 - 1. Manufacturer's name.
 - 2. Model number.
 - 3. Details of construction and installation.
 - 4. Certified load-bearing data for all curbs.
- B. Delegated-Design Submittal
 - 1. Structural calculations for anchorage systems, sealed by the Professional Engineer responsible for the design.
 - 2. Clearly indicating design criteria and loadings used.
 - 3. For each vibration isolation and seismic-restraint device.
 - a. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified Professional Engineer responsible for their preparation

1.5 PERFORMANCE REQUIREMENTS

- A. Design Responsibilities:
 - 1. Anchorage of outdoor equipment shall be designed by Contractor.
 - 2. Minimum Requirements:
 - a. Details, if any, indicated on the Drawings and Specifications contained herein are minimum requirements.
 - 1) Engineer has designed the structure to withstand the gravity and wind induced loadings of equipment.
 - 2) Notify Engineer of member size change requirements prior to fabrication.
 - b. Generally comply with layouts and configurations as indicated on the Drawings.
 - 3. Structural Performance:
 - a. Design shall be performed by a professional engineer.
 - b. Design shall comply with the building code plus amendments and local ordinances, if any, legally adopted for the location in which the Project is located.
 - c. Design anchorage systems capable of withstanding design loads within limits and under conditions indicated.
 - 1) The term "withstand" means that the unit will remain in place without separation of any parts from the device when subjected to the wind forces specified.
 - d. Design shall include systems that transfer gravity and wind induced loadings (including lateral, overturning and uplift effects) to the structure, including, but not limited to:
 - 1) Anchorage between units and curbs.
 - 2) Anchorage between curbs and building structure.
 - 3) Spacers, blocking, straps and the like.
 - 4. Design Loads:
 - a. Dead Loads: Actual weights of materials and fixed equipment, as calculated by designer.
 - b. Wind-Restraint Loading:
 - 1) Basic Wind Speed: 120 mph.
 - 2) Determined by designer in accordance with the basic parameters indicated on the Drawings and procedures indicated in the Building Code.
 - 3) Design shall not consider shielding by adjacent structures.

1.6 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed submittals.
- B. Codes and Standards: "Architectural Sheet Metal Manual" as published by SMACNA.
- C. Delegated Designer Qualifications:
 - 1. Professional Engineer licensed in the state in which the Project is located.
 - 2. Having experience in a minimum of 5 projects in the last 10 years of comparable or greater complexity

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Pipe Seals and Boots:
 - 1. The Pate Company.
 - 2. Portals Plus, Inc.
 - 3. Roof Products and Systems Corporation.
 - 4. Thunderline Corporation.
 - 5. Thycurb Corporation.
- B. Modular Mechanical Seals:
 - 1. Thunderline/Link-Seal.
 - 2. As approved.

- C. Backer Rod: Industrial Thermo Polymers, "Standard Backer Rod".
- D. Expanding Resilient Foam: General Electric, "RTF762."

2.2 MATERIALS

- A. Backer Rod:
 - 1. Extruded round, closed cell, polyethylene foam.
 - 2. Resilient, non-exuding.
 - 3. Density: 2.0 pounds per cubic foot.
 - 4. Tensile Strength: 50 psi.
 - 5. Nonabsorbent to water and gasoline.
 - 6. Suitable for use as a backing for acoustical sealant.
 - 7. Compatible with sealant and approved by sealant Manufacturer.
- B. Packing Material for Penetrations:
 - 1. Glass Fiber or Mineral Fiber:
 - a. Noncombustible.
 - b. Resistant to water, mildew, and vermin.
 - 2. Expanding Resilient Foams:
 - a. Acceptable alternative if manufactured for this purpose.
 - b. Minimum material density: 60 pounds per cubic foot.
 - 3. Fire-Rated Penetrations: Permanently flexible, approved firestop putty.

2.3 SLEEVES

- A. Materials:
 - 1. 18-Gage Galvanized Steel:
 - a. For ductwork openings.
 - b. For pipe penetrations in non-bearings walls.
 - 2. Schedule 40 Steel Pipe:
 - a. For all bearing walls.
 - b. For all floors.
 - c. For all concrete or masonry walls.
 - 3. Cast Iron Pipe: For all exterior below grade installations.
- B. Size All Sleeves:
 - 1. To allow for movement due to expansion, without contact to pipe or insulation.
 - 2. As indicated on the Drawings.

2.4 MANUFACTURED UNITS

- A. Exterior Wall or Roof Pipe Opening Seals:
 - 1. Compatible with installation conditions.
 - 2. Equal to One of the Following:
 - a. Pate "Pipe Seal".
 - b. Pate "Pipe Curb Assembly".
 - 3. Link-Seal.

PART 3 - EXECUTION

3.1 ROOF OPENINGS

- A. Piping:
 - 1. As indicated on the Drawings.
 - 2. For Multiple Pipes Through Single Opening: Select sleeve or opening seals of ample size to accommodate pipes.

3. Fill Annulus Opening:
 - a. Use non-combustible insulation material.
 - b. Full depth of sleeve.
4. Provide Moisture Protection Using Premanufactured:
 - a. Elastomeric boot.
 - b. Metal hood.
 - c. Flashing fitting.

- B. Locate curbs and sleeves a minimum of 12 inches from walls to permit proper flashing.

END OF SECTION 23 05 31

SECTION 23 05 46 – SOUND AND VIBRATION CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all equipment for and related items incidental to isolation and attenuation of mechanical vibration and sound:
 - 1. Major Items: Install mechanical equipment, piping and ductwork on, or suspended from, approved and specified foundations or supports.
 - 2. All vibration isolation devices shall be furnished by a single Manufacturer.
- B. Division of Work: In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
 - 1. General Contractor: Provide concrete equipment pads.
 - 2. Mechanical Subcontractor:
 - a. Provide miscellaneous structural steel necessary for support of mechanical work.
 - b. Coordinate necessary alterations in structural steel.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASHRAE - 2015 Handbook - Table 47 of Chapter 48 - "Selection Guide for Vibration Isolation".

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

- A. The isolation materials Manufacturer shall be responsible for the proper selection of isolators to achieve the specified minimum static deflections, for all isolators, based on the actual weight distribution of equipment to be isolated.
- B. Be responsible for verifying the completeness of the isolation installation and the overall suitability of the equipment to meet the intent of this Specification. All additional equipment needed to meet the intent of this Specification, even if not specifically mentioned herein or in the Contract Documents, shall be supplied by the Contractor without claim for additional payment.

1.5 SUBMITTALS

- A. Manufacturer's Literature: For all products described under Part 2 of these Specifications.
 - 1. General:
 - a. Dimensions.
 - b. Construction details.
 - c. Manufacturer's name.
 - d. Model number.
 - 2. Spring Isolators:
 - a. Rated deflection.
 - b. Spring constant.
 - c. Model number.
 - d. Type of isolator.
 - e. Size.
 - f. Height when uncompressed and maximum allowed static deflection.

- g. Isolator location shown on an outline of the isolated equipment.
 - h. Detail drawings of inertia bases isolators.
 - i. Location of isolators on plan drawings of the isolated area, where applicable.
 - j. The weight of all isolated equipment, and the loads on each isolator and the static deflection of each isolator under the specific design load shall be listed along with the proposed isolators.
 - k. Pipe isolators shall be shown and identified on piping layout Drawings.
- B. Furnish a complete set of approved Shop Drawings of all mechanical and electrical equipment to receive vibration isolation devices to the vibration isolation materials Manufacturer, based upon the selection of vibration isolators and design of supplementary bases will be completed. The Shop Drawings to be furnished shall include operating weights of the equipment to be isolated and the distribution of weight at support points.

1.6 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
- 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
- B. Manufacturer or Qualified Representative Services:
- 1. Provide necessary field supervision.
 - 2. Ensure correct installation and adjustment.
- C. Regulatory Agencies Requirements: Comply with all state and local codes and ordinances.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. All materials shall be delivered in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Vibration Control: All vibration control apparatus shall be provided by a single Manufacturer except as specifically noted herein:
- 1. Amber-Booth.
 - 2. Mason Industries, Inc.
 - 3. Vibron.
 - 4. Kinetics.

2.2 VIBRATION ISOLATION EQUIPMENT

- A. Isolation Pads:
- 1. Isolator Type WP:
 - a. Type WP (waffle pads) shall be 5/16-inch (8 mm) thick neoprene pads, ribbed or waffled on both sides. The pads shall be selected for 15% strain. Where required, steel load-spreading plates shall be incorporated between the equipment and the neoprene pad. Neoprene shall be bridge-bearing quality with a maximum durometer (Shore A scale) of 50.
 - b. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
 - c. Type WP: Mason Industries Type W; or as approved by Engineer.

2. Isolator Type MWP:
 - a. Type MWP (metal and waffle sandwich pads) shall consist of two 5/16-inch (8 mm) thick ribbed or waffle neoprene pads sandwiching a 16 gage stainless or galvanized steel shim plate. The pad shall be designed for 15% strain. Neoprene shall be bridge-bearing quality with a maximum durometer (Shore A scale) of 50.
 - b. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660, or as approved) shall be installed under the bolt head between the steel washer and the base plate.
 - c. Type MWP: Mason Industries Type WSW; or as approved by Engineer.
 3. Isolator Type DDNM:
 - a. Type DDNM (double deflection neoprene mounts) shall be laterally stable, double deflecting, molded neoprene isolators. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed and bolt holes shall be provided in the base. The mounts shall have leveling bolts rigidly secured to the equipment.
 - b. The strain on the neoprene shall not exceed 15%. DDNM mounts shall be selected for a static deflection of 3/8-inch (9 mm) unless otherwise specified. Neoprene shall be bridge-bearing quality with a maximum durometer (Shore A scale) of 50.
 - c. Type DDNM: Mason Industries Type ND; or as approved by Engineer.
 4. Isolator Type RBA:
 - a. Type RBA isolators shall be designed with a neoprene element to provide isolation in tension, shear or compression. Neoprene shall be bridge-bearing quality with a maximum durometer of 50.
 - b. Type RBA: Mason Industries Type RBA; or as approved by Engineer.
- B. Isolation Hangers:
1. Isolator Type DDNH:
 - a. Type DDNH (double deflection neoprene hangers) shall consist of a molded neoprene isolating element in a steel hanger box. A neoprene grommet extending from and continuous with the main neoprene element shall be provided where the lower hanger rod passes through the steel hanger box, such that the hanger rod cannot contact the steel hanger. The diameter of the clear hole in the hanger box shall be at least 3/4-inch (19 mm) larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30-degree arc. When installed, the hanger box shall be allowed to rotate through a full 360 degrees without encountering any obstructions.
 - b. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3 inches (8 mm) with a strain not exceeding 15%. Neoprene shall be bridge-bearing quality with a maximum durometer (Shore A scale) of 50.
 - c. Type DDNH: Mason Industries Type HD; or as approved by Engineer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Piping or mechanical equipment shall not be hung from or supported on other equipment, pipes, or ductwork installed on vibration isolators. It shall be supported on or suspended from building structure.
- B. Equipment connected to fluid piping shall be erected on isolators or isolated foundations at correct operating heights prior to connection of piping. Equipment should be blocked-up with temporary shims to final operating height. When the system is assembled and fluid is added, the isolators shall be adjusted to allow removal of the shims, and confirm that the isolators for the fluid-filled pipes and other elements deflect the specified amounts and no more.
- C. All mechanical equipment not specifically identified in this Specification that contains rotating or vibrating elements, and all associated electrical apparatus installed by this division that contains transformers or inductors shall be installed on Type DDNM or RBA neoprene isolators as appropriate. In all such instances, submit the proposed isolators with the isolator Shop Drawings.
- D. Elastomeric isolators that will be exposed to temperatures below 32 degrees F (0 degrees C), shall be fabricated from natural rubber instead of neoprene.

3.2 MISCELLANEOUS EQUIPMENT

- A. Boilers: Each boiler shall be supported on Type DDNM isolators. Vertical and horizontal exhaust flues for gas boilers shall be supported by DDNH or DDNM isolators. In an exhaust flue, the vertical rise shall have a neoprene riser guide to limit lateral movement and to prevent solid contact to a supporting structure. There shall be a minimum clearance of 1-inch (25 mm) between the flue and the riser guide (on all sides).

3.3 FIELD QUALITY

- A. Work in accord with best trade practices, fabricate and install all items in accordance with Manufacturer's recommendations and Engineer's directions, and consult with trades doing adjoining work in order to provide an installation of first class quality.

END OF SECTION 23 05 46

SECTION 23 05 73 – TESTING AND CLEANING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes providing testing and cleaning services and the major items listed below:
 - 1. Provide all pumps, gages, valves and other equipment and material necessary to properly conduct tests and perform cleaning.
 - 2. Provide all equipment, material, labor and testing required to properly pacify hydronic system piping so that it may be integrated into the existing hydronic system with no adverse effects or contamination.
 - 3. Arrange and pay for all costs of utilities and chemicals required for the Work.
 - 4. Repair and Restore All Work Damaged:
 - a. By tests.
 - b. By cutting required in connection with the tests.

1.3 REFERENCES

- A. American National Standards Institute/Institute of Inspection Cleaning and Restoration Certification (ANSI/IICRC).
 - 1. ANSI/IICRC S520 - Standard for Professional Mold Remediation.
- B. National Fire Protection Association (NFPA):
 - 1. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - 2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

1.4 SUBMITTALS

- A. Flushing and Cleaning:
 - 1. Submit certificates for all code-required inspections.
 - 2. Submit all water Sample analysis reports as required in Part 3 of these Specifications.
- B. Pressure Test Reports:
 - 1. Submit within 1 week after each system pressure test.
 - 2. List time, date and persons present for the following for each system:
 - a. Initial tests.
 - b. Final test.
 - 3. Include report indicating:
 - a. Test type and duration.
 - b. Initial pressure.
 - c. Final pressure.
 - 4. Indicate that necessary repairs and final tests were satisfactorily completed.

1.5 QUALITY ASSURANCE

- A. Comply with all applicable codes.
- B. Secure State Health Department approval for potable water systems.
- C. Testing and Cleaning Agency:
 - 1. Minimum 15 years' experience in providing cleaning chemicals for water systems use.
 - 2. Provide regional laboratory support services.

PART 2 - PRODUCTS

2.1 CLEANING AGENT MANUFACTURERS

- A. Aqua-Chem.
- B. Aquatrol.
- C. Enerco.
- D. Nalco.

2.2 MATERIALS

- A. Detergents, solvents, and other cleaning agents shall be compatible with materials of fabrication of systems where they are used. No cleaning agent shall adversely affect materials or mechanisms in systems and cleaning agents shall be acceptable to equipment manufacturers and the Owner's environmental coordinator.
- B. Detergents, solvents, and other cleaning agents shall be compatible with process streams to be handled by systems in which the cleaning agents are used.
- C. Owner will provide water for cleaning and flushing. Other cleaning fluids, agents, and equipment shall be provided by Contractor.
- D. Hydronic systems shall use the following products or an equal substitute and shall be approved by the Engineer prior to flush.
 - 1. Use a nitrite based solution, as recommended by Manufacturer, prior to any other for the removal of iron oxides from the metal surfaces, and passivation of the base metal.
 - 2. The solution shall be circulated until a steady iron concentration is reached in the circulating water. As the solution dissolves iron oxide deposits, ferric hydroxide is formed and the pH rises it is necessary to maintain a pH range of 9 to 9.5. Therefore, supplemental feeding of the solution may be required in extremely dirty systems.
 - 3. A sodium nitrite based corrosion protection shall be placed in the pacified pipe after the system has been cleaned and flushed.
- E. Provide all necessary temporary equipment required for cleaning and flushing operations.
- F. Pipe Cleaning:
 - 1. Provide permanent hose connections for supply, discharge and recirculating lines for the new piping system.
 - 2. Provide piping at the ends of the main and branch lines of the piping system as required to accomplish flush of the piping.
 - 3. Provide a temporary pump of sufficient head and GPM required to achieve a flushing velocity of at least 10 feet per second.
 - 4. Provide temporary chemical skids with tote tanks as required for mixing chemicals and serving as a source reservoir and/or collection point for cleaning and flushing solutions.
 - 5. Provide temporary bag filters (with filter bags) as required for removal of contaminants from flushing process.
 - 6. Provide all hose, electrical leads and supply connections for completion of system required to fill, drain and refill of the lines utilizing plant supplied water and power.

PART 3 - EXECUTION

3.1 PIPING SYSTEM PRESSURE TEST

- A. General:
1. Perform all tests before piping is painted, covered, concealed or backfilled.
 2. Before testing, remove or otherwise protect from damage, control devices, air vents, fixtures, meters, or other parts which are not designated to withstand test pressures.
- B. Test Procedures:
1. Air Test:
 - a. Charge with air to the test pressure specified.
 - b. When possible, perform test when ambient air temperature is constant.
 2. Soap Test:
 - a. Charge with air, water or carbon dioxide to pressure specified.
 - b. Examine all joints for leaks with a soap suds solution.
 3. Water Test:
 - a. Charge with water to the pressure specified.
 - b. Exterior Surface of Pipe and Fittings:
 - 1) Show no cracks or other form of leaks.
 - 2) Completely drip dry.
- C. Pressure Test Criteria:
1. Test criteria below are minimum requirements. In addition, the requirements of State and Local Codes having jurisdiction shall be met:

| Piping System | Type Test | Pressure | Allowable Pressure Drop | Minimum Test Duration |
|--|-----------|----------|-------------------------|-----------------------|
| Drainage System | Water | 5 psig | 0 psi | 30 Minutes |
| Hydronic | Water | 100 psig | 2 psi | 8 Hours |
| Gas * | * | * | * | * |
| * See below for natural gas piping pressure tests. | | | | |

2. Natural Gas Piping:
 - a. Natural gas piping shall be tested in accordance with NFPA 54, Sections 8.1.4.2 and 8.1.4.3.
 - b. Test pressure to be used shall be no less than 1-1/2 times the proposed maximum working pressure, but not less than 3 psi.
 - c. Where the test pressure exceeds 125 psi (862 kPa), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe.
 - d. Test duration shall be not less than 1/2 hour for each 500 cubic feet (14 cubic meter) of pipe volume or fraction thereof. When testing a system having a volume less than 10 cubic feet, the test duration shall be a minimum of 10 minutes. The duration of the test shall not be required to exceed 24 hours.

3.2 PIPE FLUSHING AND CLEANING PROCEDURES

- A. Prior to Flushing:
1. Remove orifice plates, traps, strainer elements, flow control valves, etc. prior to or during process of cleaning. Remove instruments which might be damaged by cleaning procedures. Replace such items with spool pieces, plugs, or blind flanges. A "blind list" shall be prepared listing where blinds have been installed for cleaning and shall be provided to Owner after cleaning is complete to verify that all blinds have been removed.
 2. Items removed from piping system shall be cleaned separately.
 3. Lock valves in open position.
 4. Use new gaskets and thread lubricants when removed items are reinstalled after cleaning.

5. Temporary Bypass Piping: Provide full size bypass piping and valves at coils and heat exchangers such that the coils and heat exchangers can be isolated.
 6. Temporary Strainers: Disconnect piping to be flushed from equipment or install temporary strainers immediately upstream of such equipment.
- B. System Protection:
1. Protect piping and equipment against overpressure, collapse from vacuum, and hydraulic shock during flushing and draining procedures.
 2. Install high point vents and low point drains required to remove trapped air and to drain flushing liquid.
- C. Hydronic Piping Systems Flushing and Cleaning:
1. Thoroughly flush with water to remove pipe dope, slushing compounds, oils, welding slag, loose mill scale and other extraneous materials. Open all valves to ensure cleaning of entire system.
 2. Apply detergent and operate system in accordance with water treatment service organizations recommendations, circulating for a minimum of 8 hours:
 - a. Use only equipment and chemicals furnished by a qualified water treatment service organization.
 - b. Determine loop capacity by metering fill with all air bled out.
 - c. Isolate alkaline cleaners from cooling towers and aluminum and galvanized surfaces.
 - d. Place all control valves in open position for filling and venting.
 3. Flush through the piping mains from the extreme end to extreme end of the system until solution is well mixed and stable. Recirculate the water through the piping system until the desired cleanliness has been achieved. If the water is very dirty and the tote tank does not provide enough settling time to remove the debris prior to being suctioned out by the Contractor provided recirculation pumps, install a temporary bag housing with a filter or wire mesh strainer in the flowpath.
 4. After the mains have been flushed, flush the branch lines starting with the branch closest to the supply point and progress toward the extreme end of the piping that is furthest from the source. Repeat the flushing through each branch until the desired cleanliness has been achieved.
 5. Collect water samples and label them with a location and time/date, for analysis of cleanliness. Continue to sample the new piping system piping until it is completely flushed clean of all contaminants and matches the influent source for cleanliness.
 6. When desired cleanliness has been achieved, drain all flushing water from the system and then refilled, circulated throughout the mains and branches to rinse out the flushing chemicals, and dumped again.
 7. Restore all piping to its design state (remove all temporary piping and close all valves), and refill the system with water and the proper amount of pacifying chemical as directed by the chemical supplier. Recirculate the chemicals throughout the system for a sufficient amount of time as the chemical supplier requires for proper mixing and metal exposure.
- D. Natural Gas Piping Systems:
1. Blow clear using oil-free compressed air.
 2. Prior to pressure testing and final equipment connection.
- E. Steam and Condensate Piping Systems:
1. Steam and condensate piping systems shall be thoroughly blown out with steam using full design operating pressure, to assure complete removal of all foreign matter after pressure testing.
 2. All steam lines will be cleaned via a series of steam blows.
 3. All steam blowing must be coordinated and witnessed by the Owner or their representative.
 4. Temporary blow out piping shall be checked for proper anchoring and safe discharge outside the building. They should be able to withstand the excessive reaction forces of steam blowing. The exhaust area suitably fenced and ' CAUTION ' notice displayed prominently.
 5. All temporary piping to atmosphere and temporary supports to conduct the steam blow shall be furnished and installed by the Contractor.
 6. Blow Piping Until Clear:
 - a. With all main drips and dirt legs open to atmosphere.
 - b. As required to free system of all foreign material.

3.3 CLEANING AND FINISHING

- A. After tests have been made and the system pronounced tight:
 - 1. Clean piping and equipment.
 - 2. Lubricate bearings.
- B. Final cleaning includes but is not limited to the following:
 - 1. Equipment with Factory Finishes:
 - a. Wash factory-finished equipment with mild soap and water and leave in first-class condition, entirely free of stains or streaks.
 - b. Do not use abrasive materials.
 - c. Touch up scratches or other violations of the factory finish paint with matching paint from the equipment Manufacturer.

END OF SECTION 23 05 73

SECTION 23 07 19 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of piping insulation.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASTM Specifications:
 - a. B209 - Aluminum and Aluminum Alloy Sheet and Plate.
 - b. C533 - Calcium Silicate Block and Pipe Thermal Insulation.
 - c. C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - d. C547 - Mineral Fiber Preformed Pipe Insulation.
 - e. C552 - Cellular Glass Block and Pipe Thermal Insulation.
 - 2. ASTM Standard Test Methods: E84 - Surface Burning Characteristics of Building Materials.
 - 3. National Fire Protection Association (NFPA) publications: NFPA 255 - Surface Burning Characteristics of Building Materials: 25, 50, 50 flame spread, fuel, smoke.
 - 4. ASHRAE: 90A - Energy Conservation in New Building Design, current edition.

1.4 SUBMITTALS

- A. Manufacturer's Literature: For piping insulation.
 - 1. For Each Type Used:
 - a. Name of Manufacturer.
 - b. Details of construction and installation.
 - c. Manufacturer's data (density, K-factor).
 - 2. For Each Application:
 - a. Thickness.
 - b. Total "R" value.
 - c. Jacket material.

1.5 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in original, unbroken, brand marked containers or wrapping as applicable. Handle and store materials in a manner which will prevent deterioration and contamination with foreign matter.
- B. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace removed materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Insulation:
 - 1. Pittsburgh-Corning.
 - 2. Owens-Corning.
 - 3. Certainteed.
 - 4. Armacell.
 - 5. Rubatex.
 - 6. Knauf.
 - 7. Johns Manville.
- B. Jacketing (Aluminum or PVC):
 - 1. Ceel-Co.
 - 2. O'Brien.
 - 3. Zeston.
 - 4. Childers.
 - 5. Pabco.
- C. Adhesives:
 - 1. Foster.
 - 2. Childers.
 - 3. Vimasco.
 - 4. B.E.H.
 - 5. Or approved equal.

2.2 TYPES OF INSULATION MATERIALS

- A. Rigid Molded Glass Fiber – General (FG):
 - 1. All-service jacket (ASJ) type factory applied jacketing.
 - 2. 3 lbs/cu ft minimum density.
 - 3. k factor of 0.23 at 75 degrees F mean.
 - 4. 50 degree F service temperature.
 - 5. Owens-Corning Type ASJ Max Pipe Insulation with SSL Max closure system; or equal.
 - 6. Typical for application on pipes 16 inches and up.
- B. Calcium Silicate (CS):
 - 1. Rigid, molded asbestos-free hydrous calcium silicate.
 - 2. k factor of 0.41 maximum at 200 degrees F mean.
 - 3. 14.5 lbs/cu ft minimum density.
 - 4. Certainteed "Calmax," Johns Manville "Thermo-12 Gold;" or equal.
- C. Mineral-Fiber Insulation (MF):
 - 1. Preformed Pipe Insulation:
 - a. Type I, 850 Degrees F (454 Degrees C) Materials:
 - 1) Mineral or glass fibers bonded with a thermosetting resin.
 - 2) Comply with ASTM C547, Type I, Grade A, without factory applied jacket.
 - b. Johns Manville "Micro-Lok;" or equal.
 - 2. Pipe and Tank Insulation:
 - a. Mineral or glass fibers bonded with a thermosetting resin.
 - b. Semirigid board material complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB.
 - c. Nominal density is 2.5 lb./cu. ft. (40 kg/cu. M) or more.
 - d. Thermal conductivity (k-value) at 100 degrees F (55 degrees C) is 0.29 BTU x in./h x sq. ft. x degrees F (0.042 W/m x K) or less.
 - e. Johns Manville; MicroFlex; or equal.

2.3 INSULATION INSERTS

- A. Insulation inserts shall be made of calcium silicate treated with water repellent.
- B. Inserts shall be preformed for the pipe size, same thickness as adjoining pipe insulation, same length as shield, and 180 degree-minimum segments.
- C. Insulation inserts shall not be less than the following lengths:
 - 1. 2-1/2-Inch Pipe Size and Less: 10 inches long.
 - 2. 3-Inch to 6-Inch Pipe Size: 12 inches long.
 - 3. 8-Inch to 10-Inch Pipe Size: 16 inches long.
 - 4. 12-Inch Pipe Size and Larger: 22 inches long.

2.4 EXPANSION JOINT INSULATION

- A. Provide removable insulation blanket over both the body and slip end of the expansion joint.
- B. Comply with the requirements of Division 23 Section "Piping Specialties for HVAC."
- C. Manufacturer: Advanced Thermal Systems; or pre-approved equal.

2.5 PIPE AND FITTING COVERS

- A. Polyvinyl Chloride (PVC) Covers:
 - 1. Ultraviolet resistant.
 - 2. 0.030-inch minimum thickness.
 - 3. Preformed to match outer diameter of insulation.
 - 4. Preformed fitting covers, minimum 10 mil.
 - 5. Ceel-Tite 330; or equal, by Toplevel or Zeston.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Install piping insulation:
 - a. In conformance with the Drawings, these Specifications, and the Manufacturer's recommendations.
 - b. Over clean, dry piping system.
 - c. To the following thickness:
 - 1) As specified herein or as indicated on the Drawings.
 - 2) If not specified herein or indicated on the Drawings, in accordance with Manufacturer's recommendations for the specific application.
 - d. Continuous through walls, ceilings and sleeves except at fire stops.
 - 2. Fill all cracks and voids with insulating cement carefully troweled to leave a smooth finish.
 - 3. Repair or replace insulation damaged by:
 - a. Demolition.
 - b. Making connections to piping or equipment.
 - c. Water or mildew.
 - 4. Insulate bundles of pipes out-of-doors with complete wrap of insulation 1-1/2 inches thick and of suitable diameter to contain bundle, with outer wrap.
 - 5. Pipe Sizes 12-inch and Larger: Hold each 3-foot section of insulation in place with at least 3 separate loops of No. 14 AWG stranded annealed wire.
 - 6. Verify that piping has been tested and cycled before applying insulation materials.
 - 7. All sectional pipe covering shall be neatly and tightly applied with unbroken lengths and with the ends of the sections firmly butted together. Longitudinal joints shall be on the least conspicuous side of the pipe and slightly staggered. Fiberglass cloth or other coating shall be lapped over all joints and well pasted or cemented down in a neat and inconspicuous manner.

8. The insulation on piping shall be extended through all sleeves, anchor points and supports in order to produce a continuous application, and same shall be installed to conform to a uniform diameter.
9. All fittings, flanges, end caps, etc. on all lines, except where otherwise noted, shall be covered with insulated fitting covers. Thickness of insulation, jackets and finishes shall also match adjacent piping.
10. Secure calcium silicate pipe insulation with stainless steel bands.
11. Insulation for piping shall be continuous through hangers and supports.
12. Provide insulation inserts and insulation protection shields at hanger or support locations.
13. Valve bodies to the bonnet flange or union, drip legs, and pipes at anchor points shall be insulated. Terminate insulation into a finished end.
14. Steam traps shall not be insulated.
15. Terminate insulation into a finished end.

B. Expansion Joint Insulation:

1. Install removable insulation blanket over both slip end and body of the expansion joint. Ensure packing cylinders are properly aligned with blanket openings
2. Packing gland cylinders shall remain exposed and accessible for service.

C. Joints and Fittings:

1. Block insulate valves and flanges with reusable insulation system.
2. Insulate elbows, tube turns, sweeps and bends with mitered sections or premolded fittings. Match pipe covering material where used.
3. Fit joints tightly together.
4. Seal joints with sealing compound and preformed aluminum bands.

3.2 JACKETS AND FINISH

A. General:

1. Provide moisture barrier between the insulation and the jacketing in a continuous, unbroken seal.
2. Hold jacketing in place by a continuous sealed joint, providing a positive weatherproof seal along the entire length of the jacket.
3. Cap off ends with caps.
4. On cold lines, cut caps to the exact size of the pipe and seal with a recommended silicone calking.
5. Provide slip joints a minimum of every 25 feet or as needed for expansion.
6. Locate longitudinal jacket seams on indoor exposed piping out of view.

B. PVC:

1. Center a preformed strap (snap-strap) containing a permanently weatherproof plastic sealant over each circumferential joint and secure by tightening on a clip, or by use of a separate stainless steel banding.
2. Design snap-strap to take care of normal expansion.
3. Cover all pipe insulation and preformed insulation fittings.
4. Weld longitudinal seams together with welding adhesive as supplied by cover Manufacturer.
5. Overlap adjacent jacketing 3/4-inch and weld circumferential seams together with welding adhesive.
6. Overlap fitting covers to adjacent pipe insulation jacketing. Weld longitudinal and circumferential seams together with adhesive.

C. Attachment:

1. For systems operating at 50 degrees F and above: May be stapled using outward clinch staples spaced 3 inches apart at least 1/4-inch from the lap edge.
2. For systems operating below 50 degrees F: Vapor seal laps using self-sealing lap, lap seal tape gun or adhesive such as Benjamin Foster 520.

D. Taper and seal insulation ends regardless of service.

E. Fitting and pipe jackets to have matching finishes ready for painting.

F. For Insulation Without Factory Applied Jacket:

1. Finish with 8-ounce glass mesh and mastic.
2. Use breather mastic on piping operating at temperatures greater than 50 degrees F.
3. Use vapor barrier mastic on piping operating at temperatures less than 50 degrees F.

3.3 PIPING INSULATION APPLICATION SCHEDULE

- A. Basis of Thickness Chart:
1. Thicknesses shown are based on products having a maximum "k" factor of 0.26 at a mean temperature of 75 degrees F.
 2. These Thicknesses:
 - a. Can be reduced for products having significantly lower "k" values.
 - b. Shall be increased for products having higher "k" values in order to produce equivalent or greater thermal resistance.
- B. Flame/Smoke Ratings: Local requirements for flame and smoke ratings must be met and may exclude some options listed herein.
- C. Jackets and Finish Application: Provide PVC jacket on exposed insulated piping elbows and tees and where existing similar piping systems use PVC jackets.
- D. Thickness Chart (In Inches):
1. Key: Insulation Type (Refer to Paragraph 2.2 of this Section):
 - a. FG = Rigid Fiberglass.
 - b. MF = Mineral Fiber.
 - c. CS = Calcium Silicate.

| PIPE SIZE | | | | | | | | |
|--|---------------------|----------------|--------------|--------------|--------------|----------|---------|----------------------|
| | Piping Systems Type | Temp (F) Range | Less Than 1" | 1" to 1-1/4" | 1-1/2" to 3" | 4" to 6" | 8" & Up | Type of Insulation * |
| 1. | Steam | 306-450 | 2.5 | 3.0 | 3.0 | 4.0 | 4.0 | FG, CS, MF |
| 2. | Steam | 251-305 | 1.5 | 2.5 | 3.0 | 3.5 | 3.5 | FG, CS |
| 3. | Steam Condensate | Any | 1.5 | 2.5 | 3.0 | 3.0 | 3.0 | FG, CS, MF |
| * See PART 2 – PRODUCTS Article 2.2 TYPES for types of insulation. | | | | | | | | |

END OF SECTION 23 07 19

SECTION 23 08 00 – COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Division 01 Specification Sections, apply to this Section. Refer to Division 01 Section "General Commissioning Requirements" for detailed explanation of commissioning work. Section also contains sample construction checklist, and functional test.

1.2 SUMMARY

- A. This Section lists mechanical systems to be commissioned. The commissioning process is described in detail in the commissioning plan (Refer to Division 01 Section "General Commissioning Requirements").

1.3 SYSTEMS TO BE COMMISSIONED

- A. The following systems will be commissioned:
 - 1. Steam and Condensate System:
 - a. Boilers.
 - b. Piping.
 - c. Chemical feed.
 - d. Feedwater control.
 - 2. Building Management and Control System (BMCS):
 - a. Operator Interface functions, graphics and webpages.
 - b. Actuators.
 - c. Controls sensors.
 - d. Control valves and dampers.
 - e. Other miscellaneous alarms.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION 23 08 00

SECTION 23 09 00 – INSTRUMENTATION AND CONTROL FOR BOILER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the design, furnishing and installation of the major items listed below as indicated on the Drawings, as specified herein, and as necessary for the proper and complete performance of the Work:
1. Field instruments.
 2. The Work of this Section also includes the integration of the Work of other trades as necessary to provide a complete operational control system as defined in the Contract Documents.
- B. Major items unique to the work of this Section:
1. All remote sensing devices and interconnecting wiring or tubing.
 2. All secondary control devices including, but not necessarily limited to, the following:
 - a. Primary and secondary controllers.
 - b. Relays.
 - c. Control panels.
 - d. Operator interface.
 - e. Network devices.
 - f. Miscellaneous sensors.
 3. Electric power supply source.
 4. Conductor and conduit.
 5. Necessary appurtenances to make a complete and functional system to satisfy the functional intent.
 6. Final and complete operational demonstration.
 7. BMS interface, integration devices and programming.
- C. Mechanical systems included in the Work of this Section:
1. Except as specifically described below, it is the work of this Section to provide, install and integrate complete control of the HVAC systems, including, but not limited to the following:
 - a. Primary boiler controls:
 - 1) Boiler remote monitoring and alarming functions.
 - 2) Boiler feedwater control.
 - 3) Boiler combustion air interlock control
 - 4) Boiler burner and safety controls
 - 5) Boiler sequencer
- D. Integration:
1. Provide communication interface and network integration for the following packaged control systems furnished under the Work of other Sections:
 - a. Boiler burner and safety controls as specified in Division 23 Section "Water Tube Boilers."
 - b. Boiler sequences as specified in Division 23 Section "Water Tube Boilers."
 2. Existing Control Equipment:
 - a. Provide for interface between new controls installation and Owner's existing control and building management systems:
 - 1) As indicated on the Drawings.
 - 2) As required to satisfy the functional intent description of this Section.
 - b. All existing equipment is assumed to be fully functional and in proper working order as it relates to the work of this Section for Base Bid.
- E. Installation and field wiring of equipment furnished under other Sections: See Division 23 Section "Water Tube Boilers".

- F. Field demonstrations and commissioning shall include verification of each I/O point at human machine interfaces (HMI) in the Boiler Control Panel. Zero/span each instrument for HMI verification.

1.3 DIVISION OF WORK

- A. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades.
- B. The following are suggestions as to how the Work may be divided. This is not intended to be a complete list of all the Work:
 - 1. Mechanical Subcontractor:
 - a. Install separable wells that are specified to be supplied by HI&C Subcontractor.
 - b. Provide all necessary valved pressure taps, steam, water drain and overflow connections and piping.
 - c. Provide all necessary piping connections.
 - 2. Electrical Subcontractor:
 - a. Provide conduit, conductors, and wire for all 120 volt or higher devices which interlock equipment provided under Division 23 with equipment and devices provided under other Divisions of the Specifications as indicated on Electrical Drawings and Division 26 Specifications.
 - b. Provide power to DDC panels as indicated on the Drawings.
 - c. Provide devices, conduit and wiring as indicated on Electrical Drawings.
 - 3. HI&C Subcontractor:
 - a. Be responsible for controls systems operation in accordance with sequence of operations description defined in Division 23 Section "Sequences of Operation for HVAC."
 - b. Wire all 120 volt and lower voltage sensing devices and level controls.
 - c. Make final terminations to controlled components.
 - d. Provide conductors and conduit, including low voltage and 120 volt, as required to provide functional intent, except as specifically indicated otherwise on Drawings or in the specifications.
 - e. Provide all interface devices necessary for required communication to other systems.
 - f. Provide for power supply for all DDC panels that are required that are in addition to those indicated on the Drawings.
 - g. Operate all control devices to confirm sequence of operations. Support Commissioning Authority in functional performance testing in accordance with the requirements of Division 23 Section "Commissioning of HVAC."
 - h. Provide certification to Commissioning Authority of complete control system function and calibration.
 - 4. Commissioning Authority (CxA): Provide verification of system function in conformance with design intent, including selected sensor calibration.

1.4 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the Work of this Section shall comply with the following:
 - 1. ANSI - American National Standards Institute:
 - a. ANSI/ISA S5.1 - 1984 - Instrumentation Symbols and Identification (Joint Standard with ISA - Instrument Society of America).
 - b. ANSI X3.4 (ASCII).
 - c. ANSI/ASHRAE Standard 135 - BACNet.
 - d. ANSI/EIA Standard 709 - Control Network Protocol Specification (LONWorks).
 - 2. EIA - Electronic Industry Association: EIA Standard RS-232-C.
 - 3. NFPA – National Fire Protection Association:
 - a. 70 – National Electrical Code.
 - b. 90A – Standard for the Installation of Air-Conditioning and Ventilation Systems.

1.5 DEFINITIONS

- A. Where applicable, the terminology used herein uses the definitions listed in ASHRAE Standard 13.

- B. Other definitions used include:
1. Low Voltage:
 - a. Voltage less than 120V single phase, typically 24V AC.
 - b. Low voltage is used primarily for communication and control of devices.
 2. Large Valves: Valves for piping greater than 2 inches in diameter.
 3. DDC: Direct digital controls.
 4. IP: Internet protocol.
 5. LAN: Local area network.
 6. HVAC: Heating, ventilating and air conditioning systems. Generally, the work of Division 23.
 7. Secondary Controller:
 - a. Application Specific Device or Controller: A sensor, controller, or end device that is pre-programmed by the vendor. It may have physical inputs and physical outputs. The control logic, while not programmable, may be configurable through the use of configuration parameters. The application may require input network variables and may send output network variables onto the network.
 8. Control Logic Diagram: A graphical representation of control logic for the multiple processes that make up a system. Logic symbols are used to represent:
 - a. Input/Output (I/O) data.
 - b. Control functions such as PID, two-position control, switches, etc.
 - c. Math functions such as addition, subtraction, multiplication, division, etc.
 - d. Boolean functions such as greater than, less than, equal to, etc.
 - e. Limit functions such as maximum, minimum, ramps, etc.
 9. Managed Communication: The transmission of data from a controller to a data manager, which in turn rebroadcasts the data to a second controller. The data manager may be referred to a network controller.
 10. Peer to Peer Communication: Data is broadcast from its origin and is received by the final device requiring the data without being received and retransmitted by a third device.
 11. Standalone Controller: A standalone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A standalone controller will also have data management features such as time schedules, trend data storage and alarm message generation capabilities.
 12. TCP/IP: Transmission Control Protocol/Internet Protocol. A basic communications protocol in a private network, either an intranet or an extranet.

1.6 DESIGN AND PERFORMANCE REQUIREMENTS

- A. System layout and design responsibility are included as Work of this Section:
1. Details of construction, quantities, components and accessories indicated on the Drawings and in the Specifications are minimum requirements.
 2. Increases in system component requirements beyond these minimums that are determined by the system designer to be necessary to provide the functional intent and for a complete system shall not be a basis for an increase in cost to Owner. Refer to Division 23 Section "Sequences of Operation for HVAC" for functional intent.
- B. Comply with the following performance requirements:
1. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within 5 seconds of each other.
 2. Performance: Programmable controllers shall execute DDC/PID control loops, and scan and update process values and outputs at least once per second.

1.7 SUBMITTALS

- A. Submit the following in accordance with Division 01.
- B. Submittals Prior to Construction:
1. A description of the complete system, including a schematic diagram showing system architecture and all major components, cabinets, panels, sensors, controllers, hubs and operated devices, and required cabling between each.
 - a. Include any environmental and space requirements for equipment.

- b. Anticipated deviations from performance and response time specified.
 - c. A layout drawing indicating locations of controllers and major devices.
 - 2. Sensors, Controllers and Related Devices:
 - a. Complete system wiring diagrams and/or piping schematic including motor starters.
 - b. Specification sheets on all individual control system components, including rated accuracy of sensors.
 - c. Schedule of valves and dampers including size and performance characteristics.
 - 3. Complete Descriptions of Operation:
 - a. Written sequences for software and hard-wired controls.
 - b. A sequence of control for each system being controlled. Include the following as a minimum.
 - 1) Process control sequence for each end device.
 - 2) Supervisory logic sequence of control for each system.
 - 3) A list of all physical inputs and outputs associated with each sequence.
 - 4) Within the sequence of control, all application parameters that are to be user adjustable from an operator work station (OWS) shall be annotated with (adj) after the name of the parameter. This shall include setpoints, reset schedule parameters, calibration offsets, timer settings, control loop parameters such as gain, integral time constant, sample rates, differentials, etc.
 - 5) Within the sequence of control, all calculated values that are to be viewable at the OWS shall be annotated with (rpt) after the name.
 - 6) All points that shall be subject to manual control from an operator workstation.
 - 7) A list of all alarm points, a description of the alarm and a description of the alarm criteria.
 - 8) A list of all variables for which historical trending will be applied, the sample rates and any criteria used to start and stop the historical trending.
 - 4. Graphic Pages: Submit a sample graphic page for each type of page described in the specification section of graphic pages.
 - 5. Wiring diagrams.
 - 6. System Schematics: Include systems furnished by others that are integrated into the DDC system.
 - 7. Information of a general, non-project specific nature is not acceptable.
 - 8. Start-up Testing Plan: Submit a start-up testing plan for each unique system.
 - a. The purpose of a start-up test is to demonstrate the "completeness" of the physical tasks associated with installation and the physical performance of the components.
- C. Submittals After Construction:
 - 1. Start-up Testing Report:
 - a. Start-up testing reports shall be submitted on a per system basis.
 - b. Start-up testing reports shall be the documented results of the executed start-up testing plans.
 - 2. Operating and Maintenance Instructions: For all system components requiring maintenance include all maintenance information as required in Division 1, in addition to the following:
 - a. Descriptive System Information: Include system logic schematics, input/output functions and Sequences of Operation.
 - b. Operating Instructions: Include schedules and procedures for starting, stopping, cleaning, protection, testing, adjustments, calibration and replacement of components.
 - 3. As-Built Documentation:
 - a. Upon completion of the installation, and prior to acceptance by the Owner's representative, HI&C Contractor shall furnish as-built documentation and should include, but is not limited to the following:
 - 1) Points list in accordance with processor.
 - 2) Process flow diagram.
 - 3) Location plans.
 - 4) Operating sequences.
 - b. All changes to the above submitted drawings, equipment descriptions and operation manuals shall be clearly identified on the as-built documentation.

1.8 QUALITY ASSURANCE

- A. Fabrication, Programming and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
 - 3. 3 years minimum experience in the design and installation of HI&C work similar to that specified herein.

- B. Regulatory Agencies Requirements:
 - 1. All control wiring shall comply with NEC.
 - 2. All DDC I/O Devices (Specified and Future):
 - a. ASCII (American Standard Code for Information Interchange) coded.
 - b. Furnished with EIA (Electronic Industries Association) interface hardware.
 - 3. All instrumentation hardware shall be ISA (Instrument Society of America) compatible.
 - 4. All primary components of DDC hardware shall be UL listed (UL916).
 - 5. Installation shall comply with FCC (Federal Communications Commission) rules for Class A and Class B computing devices pursuant to Subpart J of Part 15.
 - 6. ASHRAE Standard 135, BACnet/IP.
 - 7. Network wiring shall comply with EIA/TIA Standards.

1.9 WARRANTY

- A. In addition to the warranty provisions defined in the General Conditions, provide an extended warranty of a minimum 1 additional year (2 years total).

1.10 SERVICE AGREEMENT

- A. Provide 12-month service and maintenance contract paid in full:
 - 1. Within 30 days after Substantial Completion.
 - 2. Signed by Manufacturer's authorized representative.
- B. Programming and Setpoint Adjustments:
 - 1. In addition to service and maintenance, include 10 hours for adjustments in setpoints, reset schedules, and sequence revisions as directed by the Owner to "fine tune" control systems to building and occupant characteristics through 1 year of seasonal changes under full operation.
 - 2. Documentation:
 - a. Submit documentation of actual time spent for programming and setpoint adjustments within 30 days after completion of the work for approval by Owner or Engineer.
 - b. Time spent for service and maintenance as included above is not part of this allotment and is to be documented separately.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

- A. The Owner shall retain all rights to software for this project.
- B. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
 - 1. Configuration tools.
 - 2. Addressing tools.
 - 3. Application files.
 - 4. Configuration files.
 - 5. Graphic files.
 - 6. Report files.
 - 7. Graphic symbol libraries.
 - 8. All documentation.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. General:
 - 1. All controlled components, sensors and controllers shall be addressable.
 - 2. Provide completely computerized system using low voltage electricity as the operating medium.
 - 3. System Functions:
 - a. Digital operation in accordance with preprogrammed strategies to control temperatures, energy use and selected electrical/mechanical equipment.

- b. Capable of mathematical computation and logical/relational functions as required to achieve specified control strategies.
 - c. Capable of off-loading programs and accumulated data to magnetic media and a web browser.
 - d. Provide battery-powered RAM devices for program storage.
 - e. Continuous self-checking capability.
 - f. English language message display for all alarm and fault conditions.
- B. Interoperability:
 - 1. The system specified herein is a peer-to-peer addressable, standalone distributed control system integrating both ANSI/ASHRAE Standard 135 (BACnet) and LONWorks technology and communication protocols in a common interoperable system. The system shall allow future expansion and modifications to the system with complete addressability without the use of proprietary components or software.
 - 2. All software and intelligent devices shall comply with BACnet and/or LONWorks standards to provide complete interoperability between all system components.
 - a. Each LONWorks device shall be certified for compliance with the applicable LONWorks profile, where available. Supplier shall furnish necessary external interface file (.XIF) for all uncertified devices.
 - b. Each BACnet device shall be furnished with a protocol information conformance statement (PICS) certifying compliance to a minimum of Level 3.

2.2 MANUFACTURERS:

- A. Subject to compliance with interoperability requirements and these Specifications, hardware, software, and components shall be supplied by and bear the name of 1 or more of Manufacturers listed below. Alternate Manufacturers are also listed in this Specification for individual components.
- B. Acceptable Manufacturer: Cleaver Brooks Hawk 4000; or equal (refer to boiler specification). Interface to existing BMS by Honeywell.
- C. Stocking Requirements: All valves, operators, standard electrical components, and other replaceable parts shall be normally stocked within a 100 mile radius of the job Site.
- D. Electrical Components: Provide electrical components as specified in Division 26 and as manufactured by the acceptable Manufacturers listed therein.
- E. Custom Programming:
 - 1. All custom programming must be performed in English language commands, and all inputs, outputs, variables and flags shall be addressable by user specific English names without requiring alphanumeric addresses or point numbers.
 - 2. The system shall be programmable to allow or secure each of the above setpoint controls at each level.
 - 3. Provide software graphic package, including graphical representations for all major systems:
 - a. Boilers and feedwater system.
- F. Logs/Alarms:
 - 1. Provide automatic logging of control alarms and critical alarms.
 - 2. Additional logging shall be programmable including, but not limited to:
 - a. Equipment run time.
 - b. Historic trends and logs.
 - c. User defined meters.
 - d. User access logs and point scans.
 - 3. Provide alarm monitoring and reporting capabilities for all input points, including phase loss alarms, external alarms, load control alarms, critical alarms with auto-dial-up feature, alarm summary on printer, including time and date of alarm, and programmable power-failure restart sequence.
 - 4. Audible Alarms:
 - a. Provide audible alarm at building level processor for each alarm condition.
 - b. Provide operator silencing. Reset daily.

2.3 ELECTRICAL DEVICES AND WIRING

- A. Comply with all local codes and applicable Sections in Division 26 of these Specifications.
- B. Low Voltage Wiring (24V or Less):
 - 1. Installed in a ceiling plenum used for return air shall be plenum rated wire securely fastened in accordance with the requirements of Division 26.
 - 2. Exposed wiring shall be installed in accordance with the requirements of Division 26.
- C. Approved Manufacturers:
 - 1. Honeywell.
 - 2. Siemens.
 - 3. Allen-Bradley.
 - 4. GE.
 - 5. Square D.
- D. Limit Switches: Limit switches shall be oil tight type with appropriate operator to provide required function. Limit switches used on dampers should be set at approximately 75% of full stroke.
- E. Control Relays and Contactors:
 - 1. Relays shall be a minimum DPDT, of proper coil voltage, with indicator light, and of sufficient rating for specified purpose. Relay base shall be of the screwed terminal type.
 - 2. Contactors shall be definite purpose type, have adequate number of poles, of proper coil voltage, and of sufficient rating for specified purpose.
- F. Environment:
 - 1. All devices shall be of the correct NEMA rating for the environment in which it is installed.
 - 2. Refer to Electrical Drawings for area classifications.

2.4 GAGES

- A. Comply with the requirements of Division 23 Section "Meters and Gages for HVAC Piping."

2.5 CONTROL PANELS

- A. Located within mechanical equipment rooms.
- B. UL listed for line voltage system with removable face panel.
- C. Furnish in Manufacturer's standard color.
- D. Constructed and installed in accordance with Article 409 of the NEC (NFPA 70).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Electrical Wiring:
 - 1. Motor Starters:
 - a. Provide independent control circuit to each motor starter contactor coil.
 - b. Provide a normally open interlock contact in each motor starter to indicate contactor status at DDC.
 - c. Provide one electrically separate, normally open contact to start or stop each motor controlled by the system.
 - 2. Limit Interlocks:
 - a. Wiring of limit interlocks and dampers shall include on-off-auto switch on speed controllers.
 - b. Wiring of all limit interlocks shall be such that the equipment will be de-energized in all operating positions of the starter.

3. Provide separate branch circuits for all 120 VAC power serving DDC equipment and related components.

3.2 FIELD QUALITY CONTROL

A. Demonstration and Acceptance Test:

1. Operate each and every phase of the control system separately, or in conjunction one with the other:
 - a. For a sufficient period of time to demonstrate the ability of the system to meet performance requirements in accordance with the true intent and purpose of these Specifications.
 - b. Provide for notification and approval of Engineer as required by Division 01.
2. The HI&C Subcontractor is responsible for verifying and demonstrating that each Sequence of Operation is being performed and design conditions stably maintained under operating conditions.
3. Acceptance of performance will be provided by the CxA.
4. Provide 8 hours of field service time for demonstration and acceptance test. Additional costs required due to retesting due to failure of system to perform satisfactorily shall be the responsibility of HI&C Subcontractor.
5. Trend Logging:
 - a. Submit a 2 week log in graph form of inputs and outputs on a 1/2-hour basis. As indicated on the Table (included at end of this Section), a minimum of the following systems will be included:
 - b. Data is to be provided in an electronic spreadsheet or ASCII format on electronic media.
 - c. Submit trend data at start-up and also during cold and warm weather for the systems indicated on Table at the end of this Section:

B. Operator Instruction:

1. During system commissioning, and at such time acceptable performance of the system hardware and software has been established, provide onsite operator instruction to Owner's operating personnel.
2. Operator instruction during normal working hours shall be performed by competent Manufacturer's representative familiar with the software, hardware and accessories.
3. At a time mutually agreed upon during system commissioning as stated above, provide 8 hours of instruction to Owner's designated personnel on the operation of all equipment within the system and describe its intended use with respect to the programmed functions specified.
4. Includes, but is not necessarily limited to:
 - a. The overall operational program, equipment functions (both individually and a part of the total integrated system).
 - b. Commands.
 - c. Advisories.
 - d. The appropriate operator's intervention required in responding to the system's operation.
 - e. A description of the chronological information flow from field sensors, contacts and devices to the centrally located control console.
 - f. The overview of the system's communication network to acquaint the operator of the interplay between initiating devices, remote processing units, loop communications and their importance within the operating system.
5. Provide additional information time, as deemed necessary by Owner's authorized representative, on a negotiated basis with Owner.

- #### C. Troubleshooting:
- Comply with the requirements of Division 23 Section "General HVAC Provisions," Article 1.7, for troubleshooting.

3.3 ADJUSTMENTS AND CALIBRATION

- #### A. Upon completion of this Project, adjust and validate all thermostats, controllers, valves, damper operators, relays, and other components provided as part of the temperature control system.

B. Calibration:

1. Provide calibration documentation to Engineer, which shall include:
 - a. For pressure, differential pressure, flow, and other transmitter's provide calibration curves using the zero, span and 3 other points between 10% and 90% of span. These curves shall relate the output signal of the transmitter to the primary measured value.
 - b. Indicating instruments shall read true conditions and be checked with test instruments.

- C. Adjustments, Tuning and Start-up:
1. After the completion of calibration, adjust and tune the controls.
 2. Provide documentation, which is to include:
 - a. Input/output relationship of all controllers, positioners, and final drive units.
 - b. Gains and time constants established in all controllers.
 - c. Loop setpoints.
 - d. Limits on control actions.
 - e. Alarm limits.
 - f. Control dead bands.
 3. Provide seasonal adjustments as required under Article 1.10 - Service Agreement.

| Control Systems | Trend with Warm Weather | Outdoor Air Temp | Controlled Setpoint | Source Equip On-Off Cycles |
|-----------------|-------------------------|------------------|---------------------|----------------------------|
| Boiler | X | X | X | X |

END OF SECTION 23 09 00

SECTION 23 09 93 – SEQUENCES OF OPERATION FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes control sequences for HVAC systems, subsystems and equipment as specified herein, and as necessary for the proper and complete performance of the Work.

1.3 DEFINITIONS

- A. DDC: Direct digital controls.
- B. VAV: Variable air volume.
- C. TCS: Temperature control system.

1.4 DIVISION OF WORK

- A. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the Work to be performed by specific trades.
- B. The following are suggestions as to how the Work may be divided. This is not a complete list of all the Work:
 - 1. Mechanical Subcontractor:
 - a. Be responsible for operation of all packaged controllers furnished with mechanical equipment in accordance with sequences of operation description defined in this Section.
 - b. Provide certification to Commissioning Authority of complete packaged control system function and calibration.
 - c. Operate all packaged control devices to confirm sequences of operation. Support Commissioning Authority in functional performance testing in accordance with the requirements of Division 23 Section "Commissioning of HVAC."
 - 2. Electrical Subcontractor:
 - a. Be responsible for operation of all devices interlocked with mechanical equipment as indicated on "E" series Drawings and operation of interface in accordance with sequences of operation description as defined in this Section.
 - b. Provide certification to Commissioning Authority of control device and interface function and calibration.
 - c. Operate all control devices to confirm sequences of operation. Support Commissioning Authority in functional performance testing in accordance with the requirements of Division 23 Section "Commissioning of HVAC."
 - 3. T.C.S. Subcontractor:
 - a. Be responsible for TCS operation in accordance with sequences of operation description defined in this Section.
 - b. Provide certification to Commissioning Authority of complete control system function and calibration.
 - c. Operate all temperature control devices to confirm sequences of operation. Support Commissioning Authority in functional performance testing in accordance with the requirements of Division 23 Section "Commissioning of HVAC."
 - d. Coordinate the Work of other contracts to achieve a complete, integrated mechanical control system.
 - 4. Commissioning Authority: Provide verification of system function in conformance with design intent, including selected sensor calibration.

1.5 STEAM BOILER CONTROL SEQUENCES

- A. Refer to boiler Division 23 Section "Water Tube Boilers."
- B. Existing outside air intake damper for combustion air is interlocked with boilers B-2 and B-3 burner operation to open and close accordingly. Provide an alarm to the BMS if damper doesn't prove open.
- C. Through the existing BMS and boiler water level and steam pressure inputs, control the boiler feed water pump and new modulating boiler feedwater control valves to maintain water level.
- D. The existing water meter is to control operation of the chemical feed pump.
- E. Operator Workstation: Display the following data:
 - 1. Outside temperature.
 - 2. Steam pressure.
 - 3. Boiler firing rate.
 - 4. Operating status.
 - 5. Provide monitoring and alarm points identical to existing boiler system. Coordinate with Owner.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION 23 09 93

SECTION 23 10 23 – NATURAL GAS PIPING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of natural gas piping and natural gas distribution system.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ANSI Z223.1 - Fuel Gas Code.
 - 2. ASME B31.1 - Power Piping.
 - 3. ASME B31.8 - Gas Transmission and Distribution Piping Systems.
 - 4. International Fuel Gas Code, latest edition.
 - 5. NFPA 54, National Fuel Gas Code, Latest Edition.

1.4 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications: Trained and experienced in the fabrication and installation of the materials and equipment.
- B. Installation shall comply with:
 - 1. State and local codes and ordinances.
 - 2. Requirements of:
 - a. Owner's insurer.
 - b. Gas distribution utility.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration and contamination with foreign matter.
- C. Reject damaged, deteriorated or contaminated material and immediately remove from the Site. Replace removed materials at no additional cost to Owner.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. During Freezing Weather:
 - 1. Protect all materials in such a manner that no harm can be done to:
 - a. Installations already made.
 - b. Materials and equipment on the Site.
- F. Furnish all necessary protection for such installations and equipment as may be required.

PART 2 - PRODUCTS

2.1 PIPE AND FITTING APPLICATIONS:

- A. General:
 - 1. Comply with the requirements of Division 23 Section "Steel Pipe and Fittings for HVAC."
 - 2. Pipe 6'-0" and longer shall be permanently marked with the following information:
 - a. Manufacturer's name.
 - b. Pressure rating.
 - c. Size.
- B. Natural Gas – To 30 psig:
 - 1. For Piping Through 2-Inch:
 - a. Pipe: Black Steel, Schedule 40, ASTM A53 or A106, seamless, Grade B.
 - 1) Fittings: Cast Iron, ASTM EB16.4, 150 pound.
 - 2) Joints: Screwed.
 - 2. For Piping 2-1/2-Inch and Larger:
 - a. Pipe: Black Steel, Schedule 40, ASTM A53 or A106, seamless, Grade B.
 - 1) Fittings: Schedule 40, Wrought Steel, ASTM B16.9, ASTM A234.
 - 2) Joints: Welded. Flanged ASTM A181, 150 pound, forged steel at valves, and equipment.

2.2 VALVES

- A. Plug Valves:
 - 1. Aboveground:
 - a. Plug valves (gas cock) for natural gas shutoff applications shall be lubricated type equal to Homestead Figure 611 or 612 or Rockwell Figure 114 or 115.
 - b. Valves 2-inch and smaller shall be threaded. Valves 2-1/2-inch and larger shall be flanged.

2.3 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
 - 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - 4. Corrugated stainless steel tubing with polymer coating.
 - 5. Operating Pressure Rating: 0.5 psig.
 - 6. End Fittings: Zinc coated steel.
 - 7. Threaded Ends: Comply with ASME B1.20.1.
 - 8. Maximum Length: 72 inches.

2.4 PRESSURE REGULATORS

- A. General Requirements:
 - 1. Single stage and suitable for natural gas.
 - 2. Steel jacket and corrosion resistant components.
 - 3. Elevation compensator.
 - 4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.
- B. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company, Inc.
 - b. Eaton Corporation; Controls Division.
 - c. Harper Wyman Company.
 - d. Maxitrol Company.
 - e. SCP, Inc.
 - 2. Body and Diaphragm Case: Die cast aluminum.

3. Springs: Zinc plated steel; interchangeable.
4. Diaphragm Plate: Zinc plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet stabilized, mineral filled nylon.
7. Factory Applied Finish: Minimum 3 layers polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 20 psig.

PART 3 - EXECUTION

3.1 NATURAL GAS DISTRIBUTION SYSTEM

- A. Description of Work:
1. Provide complete natural gas distribution system as indicated on Drawings and as required to comply with applicable codes and regulations.
 2. This includes, but is not limited to, the following:
 - a. Connect to gas meter installation.
 - b. Vent lines to atmosphere where applicable.
 - c. Connect gas to equipment outlets.
 - d. Auxiliaries and accessories.
 - e. Provide gas pressure reducing valve at boilers.
- B. Aboveground and Indoor Piping and Installation:
1. Install gas piping and valves in accordance with the requirements of the International Fuel Gas Code, the gas company, and the NFPA 54 National Fuel Gas Code.
 2. Run gas piping and make final connections to equipment requiring gas.
 3. Install gas cock and drip in branch laterals serving each piece of equipment.
 4. Gas pipe in inaccessible locations shall not have unions, valves, tubing fittings or running threads.
 5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
 6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 7. Locate valves for easy access.
 8. Install natural gas piping at uniform grade of 2% down toward drip and sediment traps.
 9. Install piping free of sags and bends.
 10. Verify final equipment locations for roughing-in.
 11. Drips and Sediment Traps: Install drips at points where condensate may collect, including service meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
 12. Extend relief vent connections for service regulators, line regulators and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
 13. Connect branch piping from top or side of horizontal piping.
 14. Eccentric fittings or eccentric reducing couplings shall be used to make reductions. Install fittings with level side down.
 15. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
 16. Install strainer on inlet of each line pressure regulator and automatic or electrically operated valve.
 17. Install pressure gage upstream and downstream from each line regulator.
- C. Connections:
1. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas fired appliance and equipment. Install union between valve and appliances or equipment.
 2. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

END OF SECTION 23 10 23

SECTION 23 20 19 – PIPING SPECIALTIES FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of piping specialties.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASTM Specifications:
 - a. A126 - Gray Iron Castings for Valves, Flanges and Pipe Fittings.
 - b. A216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service.
 - c. A193 - Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service.
 - d. A278 - Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 degrees F.
 - 2. ANSI Standards:
 - a. B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.
 - b. B16.5 - Pipe Flanges and Flanged Fittings.
 - c. B16.24 - Bronze Pipe Flanges and Flanged Fittings, Class 150 and 300.
 - 3. ASME American Society of Mechanical Engineers:
 - a. Boiler and Pressure Vessel Code - Section II.
 - b. B31.1 - Power Piping.
 - c. B31.5 - Building Services Piping.

1.4 SUBMITTALS

- A. Manufacturer's Literature: For all items listed in PART 2 – PRODUCTS. Include dimensions, details of construction and installation, name of Manufacturer, and model.

1.5 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.

PART 2 - PRODUCTS

2.1 STRAINERS

- A. Manufacturer: Armstrong, Mueller.
- B. Type: "Y".
- C. Screen: 20 mesh brass, removable.
- D. Area: 5 times pipe diameter.
- E. Pressure Rating: Match piping.

- F. Install in front of each steam trap, pressure regulating valve and where indicated. Each strainer shall be equipped with a blow down valve and trap assembly, if on steam line.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all piping specialties in conformance with:
 - 1. The Shop Drawings reviewed by Engineer.
 - 2. The Manufacturer's recommendation.
- B. Furnish and install all vibration isolators, flexible connections, expansion joints, expansion loops required to reduce noise transmissions and stress on equipment and piping.
- C. Cold spring all piping installed with expansion joints and loops half of the total expansion. This requirement does not reduce the amount of expansion compensation required of the loop or joint.

END OF SECTION 23 20 19

SECTION 23 22 13 – STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of the steam and condensate piping systems.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. American Society of Mechanical Engineering (ASME):
 - a. B31.1 - Power Piping.
 - b. B31.9 - Building Services Piping.
 - c. Heating Boiler Code.

1.4 SUBMITTALS

- A. Shop Drawings: For all pressure reducing stations.
 - 1. Dimensions.
 - 2. Construction and installation details.
 - 3. Performance criteria, including valve Cv.
 - 4. Manufacturer/model number.
- B. Manufacturer's Literature: For all traps, vents, vacuum breakers and steam control valves.
 - 1. Manufacturer/model number.
 - 2. Size and capacity (Cv).
 - 3. Construction details.

1.5 QUALITY ASSURANCE

- A. Qualifications: All welders shall be certified per the requirements of ASME B31.1 and B31.5, as applicable.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- A. As indicated on the Drawings.
- B. Provide in accordance with the requirements of Division 23 Section "Steel Pipe and Fittings for HVAC" and as follows:
 - 1. Steam – To 60 psig – Above Ground.
 - a. For Piping Through 2-Inch:
 - 1) Pipe: Black Steel, Schedule 40, ASTM A53, ERW or seamless, Grade B.
 - 2) Fittings: Forged Steel, ASTM A181, ANSI B 16.11 unions, 250 pound ASTM A197.
 - 3) Joints: Screwed.
 - b. For Piping 2-1/2-Inch and Larger:
 - 1) Pipe: Black Steel, Schedule 40, ASTM A53, ERW or seamless, Grade B.
 - 2) Fittings: Schedule 40, wrought Steel, butt welded, black steel, ASTM A234, ASTM B16.9.
 - 3) Joints: Welded. Flanged ASTM A181, forged steel at valves, and equipment.

2. Steam – 60 to 200 psig – Above Ground:
 - a. For Piping Through 2-Inch:
 - 1) Pipe: Black steel, Schedule 40, Type S, Grade B, seamless.
 - 2) Fittings: Socket welded, forged steel.
 - 3) Joints: Welded. Forged steel, 2000 pound class.
 - b. For Piping 2-1/2-Inch and Larger:
 - 1) Pipe: Black steel, Schedule 40, Type S, Grade B, seamless.
 - 2) Fittings: Forged steel, butt welded.
 - 3) Joints: Welded. Flanged ASTM A181, forged steel at valves and equipment, 300 pound class.
3. Steam Condensate (prior to trap) – to 125 psig – Above Ground:
 - a. For Piping Through 2-Inch:
 - 1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless.
 - 2) Fittings: Schedule 80, Forged Steel, ASTM A181, ANSI B 16.11 or; unions, 250 pound ASTM A197; unions, 250 pound ASTM A197.
 - 3) Joints: Screwed.
 - b. For Piping 2-1/2-Inch and Larger:
 - 1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless, Grade B.
 - 2) Fittings: Schedule 80, Wrought Steel, ASTM B16.9, ASTM A234.
 - 3) Joints: Welded. Flanged ASTM A181, 150 pound, forged steel at valves, and equipment.
4. Steam Condensate (Gravity or Pumped After Trap) – to 60 psig - Above Ground:
 - a. For Piping Through 2-Inch:
 - 1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless.
 - 2) Fittings: Cast Iron, ASTM EB16.4, 150 pound.
 - 3) Joints: Screwed.
 - b. For Piping 2-1/2-Inch and Larger:
 - 1) Pipe: Black Steel, Schedule 80, ASTM A106, seamless, Grade B.
 - 2) Fittings: Schedule 80, Wrought Steel, ASTM B16.9, ASTM A234.
 - 3) Joints: Welded. Flanged ASTM A181, 150 pound, forged steel at valves, and equipment.

2.2 VALVES

- A. Provide in accordance with Division 23 Section “General Duty Valves for HVAC.”

2.3 STEAM TRAPS

- A. Manufacturers:
 1. Armstrong Machine Works:
 - a. This is the only manufacturer approved for inverted bucket traps when used on steam pressures less than 15 psig or downstream of a modulating valve.
 2. Spirax-Sarco.
 3. Watson-McDaniel.
 4. ITT Hoffman.
 5. Steamgard.
 6. Bestobell.
- B. Thermostatic: Cast brass body, stainless steel valve heads and seats.
- C. Float and Thermostatic: Cast semi-steel, 125 psi class body, seamless copper or stainless steel float, stainless steel valve heads and seats.
- D. Orifice: Body, nozzle and integral screen all of AISI type 300 stainless steel, as manufactured by Steamgard.
- E. Inverted Bucket: Cast semi-steel body and cap, 250 psi design/150 psi operating class, stainless steel bucket, and all stainless steel internals. Provide with thermic vent.
- F. Bimetallic: Carbon steel body (250 psig), titanium valve and seat, with chrome-alloy mechanism, as manufactured by Armstrong (SH-250) or Besto Bell (DM25). Use on superheated steam drips at 50 psig to 200 psig.

- G. Thermodynamic: Stainless steel body and disk. Rated for minimum 250 psig and 650 degrees F. Spirax-Sarco TD-42; or equal. Use on superheated steam drips at 49 psig or less.
- H. Trap Universal Connector:
 - 1. Traps shall be mounted to 360 degree universal connector able to accept multiple manufacturer thermostatic and bimetallic steam trap models.
 - 2. Manufacturers: Armstrong, Spirax Sarco; or equal.

2.4 VACUUM BREAKERS

- A. Provide manufactured unit supplied by Manufacturer listed above similar to Hoffman No. 62.
- B. Alternately, use check valve with opening force of 3-inch W.G. or less complying with the requirements of Division 23 Section "General Duty Valves for HVAC."

2.5 STEAM AIR VENTS

- A. Automatic, thermostatic balanced pressure type, with brass or semi-steel bodies, and renewable stainless steel head and seat.
- B. Phosphorus bronze thermostatic bellows, liquid filled.
- C. Provide 1 or 2 stages as required to produce flat reduced pressure curve for all ranges of capacity.

2.6 PRESSURE RELIEF VALVE

- A. ASME Section VIII rated, spring-oriented type with cast iron body and stainless steel internals.
- B. Provide pressure setting and capacity as indicated on the Drawings.
- C. Valve pressure setting compatible with system operation.
- D. 250 psig Maximum Working Pressure: 460 degrees F maximum operating temperature.
- E. Manufacturer:
 - 1. Kunkle.
 - 2. Keckley.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Piping:
 - 1. All piping shall be installed in such a way that it will be free to expand and contract, without noise, or damage to itself or to the building. It shall be the duty of this Contractor to prevent others from altering this purpose.
 - 2. All piping shall be installed in such a manner that it will NOT interfere with the necessary passage, head room or opening of doors or windows.
 - 3. Risers and vertical pipe shall be plumb, straight and have no unnecessary fittings or offsets.
 - 4. Filings, dust, or dirt shall be wiped from interior of the pipe or tubing before connections are made.
 - 5. Changes in direction shall be made with fittings.
 - 6. Vent pipes shall be installed through the roof as directed and shall be flashed as specified.
 - 7. Pitch:
 - a. Horizontal supply mains shall pitch down in the direction of flow.
 - b. The grade shall be not less than 1-inch in 40 feet.
 - 8. Reducing fittings shall be used for changes in pipe sizes, eccentric, flat on bottom.

9. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the systems.
10. Pipe not otherwise specified shall be uncoated.
11. Connections between ferrous piping and copper piping shall be electrically isolated from each other with dielectric unions.
12. Branch connections for steam and condensate shall be taken off mains on top, up at a 45 degree angle, or horizontal.

B. Steam Traps:

1. Install with union or flanged connection at both ends.
2. Provide gate valve and strainer at inlet, gate valve (and check valve) at discharge.
3. Provide minimum 10-inch (250 mm) long dirt pocket of same pipe size as apparatus return connection.
4. Do not install thermostatic elements in traps until system has been operated and dirt pockets cleared of sediment and scale. Provide temporary covers for use prior to this time.
5. Install for proper drainage of all low points of piping and equipment.
6. If orifice types are used, all traps shall be orifice type, with the exception of apparatus with constant steam pressure but variable loads (i.e., steam coil with face and bypass damper). Provide Y-type strainer with 40 MESH stainless steel insert upstream of all orifice traps.

C. Relief Valves:

1. Terminate vent lines from relief valves outdoors. Provide drip pan elbow with drain connection to nearest floor drain.
2. When several relief valve vents connect to one vent header, size header cross sectional area to equal the sum of individual vent outlet areas.

3.2 INSPECTIONS

- A. Inspections are the responsibility of the Owner and may be performed by employees of the Owner or party authorized by the Owner.
- B. Prior to initial operation, the "Non-Boiler External Piping" installation shall be inspected to ensure compliance with the engineering design and with the material, fabrication, assembly, examination and test requirements of the Code.

3.3 EXAMINATIONS

A. Visual Examinations:

1. Visual examinations are to be performed by the fabricator, erector, or a party authorized by the Owner which include visual examinations and observations.
2. Visual examinations as defined are to be performed as necessary during the fabrication and erection of the piping components to provide verification that the design and WPS requirements are being met.
3. Visual examinations shall also be performed to verify that completed welds in pipe and piping components comply with the acceptance standards specified in the Code.
4. Personnel who perform nondestructive examinations of welds shall be qualified and certified for each examination method in accordance with a program established by the employer of the personnel being certified based on the Code requirements.
5. Owner may examine welds at structural supports and pipe attachment assemblies at their discretion.

3.4 PRESSURE TESTING

A. Hydrostatic Testing:

1. Provide complete hydrostatic testing for leaks of all piping systems in accordance with ASME B31.1 "Code for Pressure Piping," latest revision.
2. Test pressure shall be at least 1.5 the design pressure, but in no cases less than 150 psig.
3. Following the application of hydrostatic test pressure for at least 4 hours, examination shall be made for leakage of the piping and at all joints and connections.
4. If leaks are found, they shall be eliminated as appropriate, and the test repeated until no leakage is found.
5. Testing must be witnessed and approved by the Engineer on each section of pipe before insulating.

- B. In-Service Leak Test for Steam and Condensate:
 - 1. An in-service test and examination using system steam is acceptable when other types of tests are not practical or when leak tightness is demonstrable due to the nature of the service; i.e., where shut-off valves are not available for isolating a line or where temporary closures are impractical.
 - 2. The in-service test shall be conducted only after receiving written authorization from the Engineer.
 - 3. This method shall also be used subsequent to pneumatic testing when used in lieu of hydrostatic testing.
 - 4. When performing an initial service test, the piping system shall be gradually brought up to normal operating pressure and temperature and continuously held for a minimum time of 10 minutes.
 - 5. Examination of leakage shall be made of joints and connections at that time.
- C. Test Procedures:
 - 1. Blank off or replace with spool pieces items of devices and equipment such as vessels, valves, instruments, etc. rated for pressure less than the test pressure. Reconnect equipment after testing.
 - 2. Perform tests before piping is covered or concealed.
 - 3. A pressure recorder shall monitor the testing of piping systems to verify test results.
- D. Cycle Testing:
 - 1. Following the completion of the leak testing procedures, the Contractor shall coordinate with the Owner's staff to conduct a cycle test on both the steam and condensate piping installed under this Contract.
 - a. All testing shall be scheduled through the Owner's with a minimum of 72 hours notice.
 - b. The cycle test may also be performed in conjunction with the in service test as authorized by the Owner.
 - c. The Contractor shall be present while the cycle test is being conducted.
 - 2. The cycle test shall consist of a single warm-up cycle and cool-down cycle where the systems are gradually brought up to normal operating pressure and temperature for a period of 8 hours.
 - 3. Prior to beginning the test, the Contractor shall mark the position of the steam and condensate expansion joints and guides at ambient conditions.
 - 4. The position of the expansion joints and guides shall also be marked after the system has been brought up to operating temperature and pressures.
 - 5. Following the cool down period, and when the system has been cooled to ambient conditions, the Contractor shall visually inspect these components including pipe slide supports to ensure their return to the initially marked position. The Contractor shall note misalignment and failure of the system to return to the original position.

3.5 CLEANING AND FLUSHING

- A. Piping shall be cleaned before the installation, and flushed after the installation and before system start up.
- B. Equipment, detergents, solvents and other cleaning agents shall be furnished by a qualified water treatment service.
- C. Disconnect piping to be flushed. Remove instruments which may be damaged by the cleaning procedures. Such items shall be replaced with spool pieces, plugs, or blind flanges.
- D. Before the piping is put in service, clean it using a pressure tank with a hose equipped with a nozzle to direct a high velocity stream of water against the inside wall of the pipe. Make a minimum of 2 passes through the pipe with the hose. A minimum pressure of 250 psi shall be developed at the nozzle.

END OF SECTION 23 22 13

SECTION 23 51 00 – BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of a complete gas vent system.
- B. Unless noted otherwise, all fuel fired appliances, whether furnished as part of Division 23 or other Divisions, including equipment that may be furnished by the Owner, is included in the venting requirements of this Work.

1.3 DESIGN AND PERFORMANCE REQUIREMENTS

- A. For use with natural gas appliances operating at neutral, positive, and negative stack pressures as indicated by equipment schedules or specified herein.
- B. Double wall vent system complete with thimbles, flashing collar and necessary fittings.
- C. Adequate support for wind stress.
- D. Vent System: Gas tight and prevent leakage of combustion products into a building.
- E. Compensate for all flue gas induced thermal expansions.
- F. Comply with fuel fired appliance Manufacturer's recommendations for vent materials and installation.

1.4 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASTM Standard:
 - a. A569 – Carbon Steel.
 - b. A36/A36M-05 – Carbon Structural Steel.
 - c. A242/A242M-04e1 – High Strength Low-Alloy Structural Steel.
 - d. A307-07a – Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
 - e. A563-07 – Carbon and Alloy Steel Nuts.
 - f. A568/A568M-07 – Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements.
 - 2. NFPA:
 - a. 54 – National Fuel Gas Code.
 - b. 211 - Standard for Chimneys, Fireplaces, Vents and Solid Fuel-Burning Appliances.
 - 3. UL:
 - a. UL 441 – Gas Vents.
 - b. UL 1738 – Standard for Safety Venting Systems for Gas Burning Appliances.

1.5 SUBMITTALS

- A. Manufacturer's Literature:
 - 1. Dimensions.
 - 2. Details of construction and installation.
 - 3. Name of Manufacturer.
 - 4. Model.

1.6 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
- B. Regulatory Agencies Requirements:
 - 1. Entire assembly shall be listed and labeled by Underwriters' Laboratories, Inc. and comply with UL Test Standard 441 - Gas Vents.
 - 2. System shall comply with applicable provisions of:
 - a. NFPA 54 - National Fuel Gas Code.
 - b. NFPA 211 - Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances.
 - 3. All state and local codes and ordinances.
 - 4. Owner's insurer.

1.7 WARRANTY

- A. Manufactured breaching and the stack shall be warranted against functional failure due to defects in material and Manufacturer's workmanship for a period of 10 years.

PART 2 - PRODUCT

2.1 PRE-FABRICATED, LISTED, VENT PIPE SYSTEMS

- A. Manufacturers:
 - 1. Selkirk Metalbestos.
 - 2. Van Packer Company.
 - 3. Metal-Fab.
 - 4. Heat Fab, Inc.
 - 5. Or Equal
- B. Pressurized Vent Stack – Double Wall:
 - 1. Stack and Breeching Vent Pipe and Fittings:
 - a. 20 gage Type 304 stainless steel inner wall.
 - b. 24 gage Aluminized steel outer wall.
 - c. 1-inch nominal air space.
 - d. Inner pipe joints shall be sealed by use of factory supplied V-bands and sealant as specified in the Manufacturer's installation instructions.
 - 2. Classification:
 - a. 1400 degrees F continuous, 1800 degrees F intermittent for chimney.
 - b. Positive, neutral, or negative stack pressures.
 - 3. Selkirk-Metalbestos Model "PS".
 - 4. Self supporting to 10 feet above roof height.

2.2 ACCESSORIES

- A. General: Provide all necessary rain caps, thimbles, flashing, supports, expansion joints, and fittings required for a complete installation.
- B. Roof Penetrations:
 - 1. Suitable for a combustible membrane roof.
 - 2. In accordance with Manufacturer's detail drawings and installation instructions.
 - 3. Refer to Division 23 Section "Penetrations for HVAC" for specific requirements.
- C. Drains: Provide threaded pipe connection to allow drainage at all low points and drain connections in stack and breeching systems. Slope piping system to the drain. Pipe size shall be 1-inch (25 mm) minimum.

- D. Instrument Ports: Locate on individual stack or breeching serving each boiler. Locate in non-turbulent zone with 12 feet (3,600 mm) of boiler room floor between boiler and economizer (when economizer is provided) or locate accessible from platform. Provide separate ports for the following:
1. Flue Gas Oxygen Analyzer: Coordinate with analyzer furnished.
 2. Opacity Monitor (if required): Coordinate with sensor furnished. Locate downstream from oxygen analyzer.
 3. Stack Temperature Sensor: Coordinate with sensor furnished.
 4. Draft Gage: 1-inch (25 mm) diameter coupling, plugged.
 5. Test Instruments: 1-inch (25 mm) diameter coupling, plugged.
 6. Access Doors: Bolted, gasketed, insulated, with handles. Provide where shown. Minimum opening 16 inches x 16 inches (400 mm x 400 mm).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Stack Termination:
1. 10 feet above roof, self supporting without the need for guying or external support.
 2. Comply with any local Codes that exceed this requirement.
- B. Route Vents as indicated on Drawings:
1. Pitch upward in direction of flow.
 2. Maintain minimum clearances from combustibles in accordance with Manufacturer's recommendations.
- C. Provide supports where necessary to eliminate any sagging or strain on vent pipe joints.
- D. Aluminized or galvanized steel surfaces exposed to the elements shall be protected by a minimum of one base coat of primer and one finished coat of corrosion resistant paint suitable for outer jacket skin temperatures of the particular installation (such as Series 4100 or 9400 as manufactured by Rust-Oleum).
- E. Joints: Provide continuous weld between boiler outlet and connecting transition, breeching or stub stack and at connections to economizers, when recommended by Manufacturer of economizer or boiler. Securely bolt all remaining joints and provide gaskets rated for service at 600 degrees F.
- F. Connect 1-inch (25 mm) minimum pipes with ball valves to breeching and stack drains. Extend to floor drain.
- G. Boiler Dampers: Locate so that there is no restriction in the flow of flue gas recirculation (if provided).

3.2 CLEANING

- A. Clean all surfaces of rust, mill scale, and apply prime coat of heat and corrosion resistant paint. Apply finish coats of heat and corrosion resistant paint to all exposed uninsulated surfaces. Select paint system compatible with maximum surface temperature.

END OF SECTION 23 51 00

SECTION 23 52 33 – WATER TUBE BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing of a field assembled and installation of a complete water tube type boiler system.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. ASME (American Society of Mechanical Engineers):
 - a. Boiler and Pressure Vessel Code Part IV.
 - b. CSD-1 - Controls and Safety Devices for Automatically Fired Boilers.
 - 2. NEMA (National Electric Manufacturer's Association): 250 - Enclosures for Electrical Equipment.
 - 3. NFPA 54 - National Fuel Gas Code.
 - 4. UL - Underwriters Laboratories:
 - a. 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
 - b. 486B - Wire Connectors for Use with Aluminum Conductors.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

- A. Boiler System:
 - 1. Field construct and assemble the boiler as a completely packaged unit with gas train, power burner, and operating and safety controls.
 - 2. Furnish sufficient tapings and openings to permit inspection and cleaning.
 - 3. Tube area shall also be accessible for cleaning.

1.5 SUBMITTALS

- A. Shop Drawings:
 - 1. Dimensions.
 - 2. Details of construction and installation.
 - 3. Name of Manufacturer.
 - 4. Model.
 - 5. List of furnished accessories.
 - 6. Performance Data:
 - a. Input and output ratings.
 - b. Efficiency.
 - c. Data at scheduled operating conditions.
 - 7. Project specific wiring diagrams including controls wiring.
- B. Operation and Maintenance Manuals:
 - 1. Equipment function, normal operating characteristics and limiting conditions.
 - 2. Operating instructions for start-up, routine and normal operating, regulation and control, and shutdown and emergency conditions.
 - 3. Lubrication and maintenance instructions.
 - 4. Guide to "troubleshooting".
 - 5. Parts lists and predicted life of parts subject to wear.
 - 6. Outline, cross-sections, assembly drawings, engineering data and wiring diagrams.

- C. State Inspection Certificate:
 - 1. Arrange and pay for inspections, including initial operating permit inspection.
 - 2. Submit to Engineer.

1.6 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed Shop Drawings.
- B. Manufacturer's Field Services:
 - 1. Manufacturer's personnel trained in field installation supervision and employed by the Manufacturer in this work for 6 months, minimum.
 - 2. Verify assembly of boilers and installation.
 - 3. Supervise and direct start-up.
 - 4. Instruct Owner's personnel in operation and maintenance procedures.
 - 5. Manufacturer's representative shall furnish experienced field support to advise contractor on assembly of boilers.
- C. Regulatory Agencies Requirements:
 - 1. ASME Boiler Code - stamped on unit.
 - 2. UL listed and labeled.
 - 3. GE GAP gas train compliant.
 - 4. Comply with all state and local Codes and ordinances.
 - 5. Comply with OSHA and MIOSHA.
 - 6. Comply with Owner's insurer.
 - 7. ASME CSD-1.
 - 8. IBR:
 - a. Tested and rated in accordance with "Testing and Rating Standard for Heating Boilers."
 - b. Bearing IBR emblem on nameplate.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which Manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of finned water tube boilers that fail in materials or workmanship within specified warranty period.
- B. Warranty Period for Heat Exchangers: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FLEXIBLE WATER TUBE BOILERS

- A. Manufacturer's:
 - 1. Bryan.
 - 2. Cleaver-Brooks.
 - 3. Unilux.
- B. Combustion Chamber: Refractory type of 2600 degrees F firebrick insulated from the base.
- C. Water Tubes:
 - 1. 1-1/2 inches O.D.
 - 2. 12 gage steel.
 - 3. Removable and replaceable without welding or rolling.
- D. Jacket and Insulation:
 - 1. Factory painted sheet metal jacket (16 gage minimum).
 - 2. Fiberglass insulation (2-1/2-inch minimum).

- E. Burner:
1. Manufacturer's:
 - a. Cleaver Brooks Profire.
 - b. Industrial Combustion.
 - c. Power Flame.
 2. Basic Construction:
 - a. Burner:
 - 1) Full modulating with 10:1 turndown and enforced low fire start.
 - 2) Equipped with a large observation port with sight glass and hinged construction to permit easy access to front furnace and burner internals without breaking any fuel lines or electrical connections.
 - 3) A safety interlock switch on unit shall prevent operation when burner is in open position.
 - 4) Furnish a proved interrupted type gas-electric pilot assembly on each unit to provide ignition.
 - b. Blower:
 - 1) An integral part of unit supplying 100% combustion air.
 3. Controls:
 - a. Fireeye; or approved equivalent; full programming flame rectification type electronic combustion safeguard using an ultraviolet scanner and providing prepurge, enforced low fire start. 10 second interrupted pilot period, main flame monitoring and post-purge.
 - b. Quick fuel shutoff shall result from flame failure, air blower failure, high gas pressure or low gas pressure.
 - c. Power control circuit by 120-1-60 electric current provided by a grounded step-down control transformer mounted on cabinet.
 - d. Install a 120-volt contact for interlocking combustion air louver with burner:
 - 1) Combustion air dampers shall open with the start of burner cycle, but shall not prevent burner from firing.
 - 2) Refer to Division 23 Section "Sequences of Operation for HVAC."
 - e. Control Cabinet:
 - 1) Dust-proof factory wired steel control cabinet mounted on channel iron supports adjacent to burner.
 - 2) Containing control transformer, fuses, magnetic motor starters, combustion safeguard chassis, on-off switch, manual purge switch, gas-oil switch and pilot lights indicating "flame failure."
 - 3) Wire cabinet components to numbered terminal strips.
 - f. Equal to Hawk 4000.
- F. Gas Train:
1. Include flow control and equipment for safe operation.
 2. Refer to the Drawings to obtain the equivalent length of gas piping ahead of the gas train to the burner manifold.
 3. Size to provide sufficient gas at the burners with gas pressure indicated.
 4. Conform to requirements of GE GAP and Owner's insurer.
- G. Fittings and Trim:
1. Furnish, install and wire the following on boiler where applicable:
 - a. Combination thermometer and pressure gage.
 - b. ASME Code rated boiler relief valve set at 150 psig.
 - c. Water temperature control aquastat.
 - d. Automatic gas valve.
 - e. Aux. gas valve.
 - f. Pilot solenoid valve.
 - g. Pilot ignition assembly.
 - h. Main manual gas shutoff valve.
 - i. Pilot cock.
 - j. Pilot and main gas pressure regulators.
 - k. Air safety switch.
 - l. Electronic flame safeguard (ultra-violet).
 - m. Extra aquastat for high limit control.
 - n. Low water cut-off (50 psig minimum working pressure).
 - o. Stack thermometer (200 degrees F to 1000 degrees F range).

- p. 250 pound angle non-return valve.
- q. Free boiler drain mounted to non-return valve.
- r. 300 pound main steam shutoff valve.
- s. Feed water stop and check valve.
- t. Feed control valve with 3 valve by-pass and strainer.
- u. 250 pound quick opening blowdown valve.
- v. 250 pound slow opening blowdown valve.
- w. Blown down piping of valves.
- x. Surface blowdown needle valve and piping of overflow connection.
- y. McDonnell Miller #193-7b water column and low water cut off.
- z. Reflex gauge glass.

H. Hawk 4000 Boiler Control System:

- 1. Description:
 - a. Each unit shall be factory equipped with a Boiler Control System providing technology and functions equal to the Cleaver Brooks Hawk 4000 Boiler Control system.
 - b. Each Boiler Control System shall be factory equipped with a pre-configured Programmable Controller and a 10-inch color touch screen Human Machine Interface (HMI).
 - 1) Major System Components shall include:
 - a) Rockwell/Allen Bradley Compact Logix Programmable Control Processor.
 - b) 10 Inch Panel View Plus Color Touch Screen HMI.
 - c) Local Modbus network for communications with Parallel Positioning Actuators, Burner Management Control and optional Variable Speed Drive, and
 - d) Various Controller Input/Output Modules.
 - e) One Burner Management Controller and Wiring Sub-Base.
 - f) One Flame Scanner: Infrared, Ultra-Violet, or UV Self-Check.
 - g) One Flame Amplifier, to correspond with the selected Flame Scanner.
 - h) Various Temperature and Pressure Sensors.
 - i) Alarm Bell
 - 2) Major functions that the Boiler Control System shall provide:
 - a) Automatic sequencing of the boiler through standby, pre-purge, pilot flame establishing period, main flame establishing period, run and post purge.
 - b) Flame proving and lockout on flame failure during pilot flame proving, main flame proving, or run.
 - c) Low fire damper/valve position for flame ignition trials.
 - d) Parallel Positioning Combustion Control for Air and maximum 3 Fuels
 - e) Yokogawa O2 Trim
 - f) Integrated Draft Control (requires external damper, low draft switch and draft transmitter. CB damper assembly includes these items as a standard)
 - g) Utilize solid state controls and sensors to provide various control functions, such as:
 - Parallel Positioning Full Modulation.
 - Modulating Control algorithm shall be Proportional-Integral-Derivative (PID) type.
 - Thermal Shock Protection with water temperature monitoring and setpoint.
 - Various High and Low limit alarms and shutdowns.
 - h) Touch Screen graphical operator interface and monitoring.
 - Minimum 10-inch Panel View Plus Color HMI.
 - Manual control of the boiler-firing rate utilizing control screens on the HMI to increment and decrement the firing rate.
 - Interface to commission boilers combustion and other system setpoints.
 - On screen real-time display of all connected process parameters.
 - On screen commissioning of boiler set points and configurable alarms.
 - On screen display of system alarms and faults.
 - i) E-mail of boiler alarms.
 - j) Basic Remote Monitoring Only Web Server.
 - k) Building/Plant Automation System interface shall be Protonode BACnet MSTP.
 - l) High Stack Flue Gas Temperature Monitoring, Cut-Off and Alarm.
 - m) Tamper resistant control logic and password protection.
 - n) Dual Setpoint (Night/Day Set Back) Capabilities.
 - o) Combustion air temperature.

- p) Boiler shell water temperature.
 - q) Assured Low Fire Cut-Off (ALFCO).
 - r) 2 Boiler Lead/Lag (Optional - Common Header Transmitter required).
 - s) Hot Standby.
 - t) PLC based expanded diagnostics with 3 Auxiliary Discrete (Digital) inputs (Only 2 available if draft control is used).
 - u) Full modulation on gas.
 - v) Alarm silencer via touch screen HMI.
- c. The Boiler Control System shall provide the following safety provisions for:
- 1) Integrated Burner Management:
 - a) Examine all load terminals to assure it is capable of recognizing the true status of the external controls, limits and interlocks. If any input fails this test, the burner management system should lockout on safety shutdown.
 - b) Closed-loop logic test verifies integrity of safety critical loads (ignition, pilot, and main fuel valves) and must be able to lockout on safety. Shutdown if any safety critical load is identified as proper or improper.
 - c) Pre-ignition interlocks (fuel valve proof of closure, etc.) and flames signal checked during Standby and Pre-Purge.
 - d) Dynamic checking of the flame signal amplifier. The control flame signal amplifier must be able to recognize a no flame signal during this dynamic amplifier check.
 - e) Safe start check and expand check to include monitoring flame signal during standby.
 - f) High and low fire switches checked for proper sequencing.
 - g) Tamper-proof purge timing and safety logic.
 - 2) Integrated Boiler Operating Controls and Security Features:
 - a) Operating and Modulating Control.
 - b) Password protection of Programmable Controller logic.
 - c) Password protection of Parallel Positioning Set Up and Commissioning screens.
 - d) Password protection of Critical Setpoint Screens.
 - 3) The Boiler Control System shall provide annunciation and diagnostics:
 - a) Active Alarm Annunciation.
 - b) Provide historical alarm information for on screen display.
 - c) Indication of failures at start up or during normal operation.
 - d) Capability of alarm history of date, time, cycle of occurrence and date and time of acknowledgement up to the most recent 100 faults.
 - e) Detects and isolates an alarm and reports internal circuit faults.
 - f) Primary and Secondary Low Water Shutdown and Alarms.
 - 4) The Boiler Control System shall be able to operate in these environmental conditions:
 - a) Supply Voltage: 120vac (+10%/-15%) 50 or 60 Hz.
 - b) Maximum Total Connected Load: 2000 VA.
 - c) Operating Temperature Limits: 32 to 130 degrees F.
 - d) 85% RH continuous, non-condensing, humidity.
 - e) 0.5G continuous vibration.
 - 5) All Boiler Control System wiring shall be in accordance with the National Electrical Codes and local electrical codes.
 - 6) System shall meet current NFP85 requirements
 - 7) Boiler Control System component functions shall be as follows:
 - a) Burner Management Controller: Provides boiler sequencing logic to meet FM/IRI/UL approval body requirements.
 - b) Touch Screen Graphical Interface (10 Inch Color Minimum): Provides user interface to the control system, boiler overview screen with connected boiler parameter readouts, alarm screens, optional water level indication and system firing rate screen.
 - c) Local Modbus Communication Network for communication with Parallel Positioning Actuators, Burner Management System, and optional Variable Speed Drive.
 - d) Various Programmable Controller Input/Output Modules: Provides interface for discrete powered and/or isolated relay signals, as well as for analog signals, to and from external devices.
 - e) Stack Temperature Sensor: Measures and transmits a signal to the Programmable Controller in relation to boiler exit flue gas temperature for indication. Also used for high stack temperature alarm and shutdown.

- f) Steam Pressure Transmitter for Steam Boilers: Provides an analog signal to the Programmable Controller for indication of boiler steam pressure. Utilized for on/off and modulating control of the burner.
- g) Water (shell) Temperature Sensor on Steam Boilers: Measures and transmits a signal to the Programmable Controller in relation to boiler water temperature. Used for indication and thermal shock protection.
- 8) Optional Equipment/Features:
 - a) Two Boiler Lead/Lag (Requires common header transmitter).
 - b) Combustion Air Temperature Sensor: Measures and transmits a signal to the Programmable Controller in relation to the combustion inlet temperature for indication.
 - c) E-Mailing of alarms capabilities.
 - d) Building/Plant automation system interface.
 - e) Revert to Pilot.
 - f) External Control Interlock: Fresh air damper.
 - g) Stack Damper Control (Open-Close).

2.2 BOILER OPERATION

- A. Refer also to Division 23 Section "Sequences of Operation for HVAC."
- B. Safety Controls:
 - 1. High and low pressure limits.
 - 2. Low water and auxiliary low water cutouts.
- C. General Boiler Operation:
 - 1. Lead/Lag Start with either Lead/Lag or Unison Modulation.
 - 2. Boilers' Start and Stop:
 - a. Steam pressure is compared with the setpoint and controller's processor executes PID algorithm. Lead boiler is commanded to come on-line first. Lag boiler 1 is commanded to come on-line when a firing rate signal for the lead boiler reaches lag boiler start point. Lag boiler 1 is commanded to stop when a firing rate signal for the lead boiler reaches lag boiler stop point.
 - b. Lag boiler 2 is commanded to come on-line when a firing rate signal for the lag boiler 1 reaches lag boiler 2 start point. Lag boiler 2 is commanded to stop when a firing rate signal for the lag boiler 1 reaches lag boiler 2 stop point.
 - c. Subsequent boilers operate in a similar fashion.
 - 3. Lead/Lag Modulation:
 - a. Lag boiler 1 starts modulation after lead boiler reaches maximum firing rate (or firing rate selected by the operator).
 - b. Lag boiler 2 starts modulation after lag boiler 1 reaches maximum firing rate (or firing rate selected by the operator).
 - c. Subsequent boilers operate in a similar fashion.
 - 4. Unison Modulation: Firing rates for all boilers are equal.
 - 5. Hot Standby: System shall have a provision for keeping lag boilers in hot standby. Standby routine shall be based on a water temperature signal.
 - 6. Firing Sequence Selection: Sequence in which boilers come on-line shall be selected via HMI. Adequate check shall be provided that does not allow improper sequence selection.
 - 7. Automatic Rotation of the Boilers: System shall be provided with a sequence to automatically rotate sequence in which the boilers are fired. Rotation shall be based on the elapsed time.
 - 8. Boiler feedwater valve is modulated based on input from boiler level controller.
- D. HMI (Human Machine Interface):
 - 1. Boiler panel shall include HMI for display and selection of the following parameters:
 - a. Display:
 - 1) Available boilers.
 - 2) Number of boilers required.
 - 3) Selected sequence of firing.
 - 4) Control output to each boiler.
 - 5) Header steam pressure.
 - 6) Setpoint.

- 7) Elapsed time from last rotation.
 - b. Selection:
 - 1) Number of boilers.
 - 2) Sequence of firing.
 - 3) Automatic or manual rotation.
 - 4) Individual boiler start and stop points with timers.
 - 5) Setpoint.
 - 6) Proportional, integral and derivative gains for control algorithm.
 - E. Application and System Requirements:
 - 1. Logic for Lead/Lag control shall reside in the Boiler Control Panels. Communication between the boiler panels shall be via Ethernet communication or hard wiring.
- 2.3 BREECHING AND CHIMNEY
- A. Refer to Division 23 Section "Breechings, Chimneys, and Stacks."
 - B. Provide venting design, material, height, and size in accordance with boiler Manufacturer's recommendations.
 - C. Provide 1/2-inch IPS capped nipple welded to breeching and extending through insulation for flue gas sampling at each boiler with a coupling of sufficient size to receive draft gage and flue gas thermometer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Rough-Ins:
 - 1. Before boiler installation, examine roughing-in for concrete equipment bases, anchor bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes and other conditions affecting boiler performance, maintenance and operations.
 - 2. Boiler locations indicated on Drawings are approximate.
 - 3. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical space for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Boiler is to be site assembled according to Manufacturer's installation instructions.
- B. Concrete Bases:
 - 1. Install dowel rods to connect concrete base to concrete floor.
 - 2. Unless otherwise indicated, install dowel rods on 18-inch (450 mm) centers around full perimeter of base.
 - 3. For supported equipment, install epoxy coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices.
 - 5. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.
 - 6. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 7. Level boilers and anchor to concrete base.
- C. Install gas fired boilers according to NFPA 54.
- D. Assemble and install boiler trim.
- E. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

- A. General: Drawings indicate general arrangement of piping, fittings and specialties.
- B. Connect gas piping full size to boiler gas train inlet with union.
- C. Connect piping to boiler tapings with shutoff valve and union or flange at each connection.
- D. Verify:
 - 1. Connect venting full size to boiler outlet.
 - 2. Refer to Division 23 Section "Breechings, Chimneys, and Stacks" for venting materials.
- E. Install piping adjacent to boiler to allow convenient service and maintenance.
- F. Ground equipment according to Division 26.
- G. Electrical Connections:
 - 1. Connect wiring according to Divisions 26.
 - 2. Tighten electrical connectors and terminals according to Manufacturer's published torque-tightening values. If Manufacturer's torque values are not indicated, use those specified in UL 486A and UL486B.

3.4 START-UP SERVICE

- A. Engage a factory authorized service representative to test, inspect and adjust boiler components and equipment installation and to perform start-up service.
- B. Perform installation and start-up checks according to Manufacturer's written instructions.
- C. Leak Test:
 - 1. Hydrostatic test.
 - 2. Repair leaks and retest until no leaks exist.
- D. Operational Test:
 - 1. Start units to confirm proper motor rotation and unit operation.
 - 2. Adjust air-fuel ratio and combustion.
- E. Controls and Safeties:
 - 1. Test and adjust.
 - 2. Replace damaged and malfunctioning controls and equipment.
- F. Adjust initial temperature setpoints.
- G. Set field adjustable switches and circuit breaker trip ranges as indicated.
- H. Occupancy Adjustments:
 - 1. When requested within 12 months of date of Substantial Completion, provide onsite assistance in adjusting system to suit actual occupied conditions.
 - 2. Provide up to 2 visits to Site outside normal occupancy hours for this purpose, without additional cost.
- I. Prepare written report that documents testing procedures and results.

3.5 DEMONSTRATION

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

END OF SECTION 23 52 33

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Electrical equipment coordination and installation.
 - 2. Common electrical installation requirements.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with
 - 1. NECA 1 - Standards Practices for Good Workmanship in Electrical Construction.
 - 2. NEC – National Electrical Code (NFPA 70)

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration, damage, contamination with foreign matter, and damage by weather or elements, and according to Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, weathertight wrapping.
- D. Reject damaged, deteriorated or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right-of-way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, and cable trays will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1 and NEC.

- B. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in a manner as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- D. Right of Way: Give to piping systems installed at a required slope.

END OF SECTION 26 05 00

SECTION 26 05 20 – CONDUCTORS AND CABLES – 600V AND BELOW

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all electrical conductors, cables, splices, and connectors.
- B. Major Systems Include:
 - 1. 600V and below feeders and electrical distribution.
 - 2. Branch circuit wiring.
 - 3. System wiring.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the standards of the following organizations as applicable to materials, construction and testing of wire cables:
 - 1. NEMA - National Electrical Manufacturer Association Standards.
 - 2. IEEE Standards.
 - 3. Insulated Cable Engineers Association - Standards.
 - 4. ASTM Standards.
 - 5. NEC - National Electric Code

1.4 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed submittals.
- B. Manufacturers: Firms regularly engaged in the manufacture of electrical conductor and cable products of the types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated, or contaminated materials and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Except as otherwise indicated, provide conductors, cables, and connectors of Manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by the Manufacturer and as required for the installation.
- B. Power Wire:
 - 1. All conductors and cables shall be new with a minimum wire size of No. 12 AWG. Manufacturer's name, type, and size shall be permanently marked on the outer covering at regular intervals and delivered in complete coils or reels.
 - 2. Provide factory fabricated conductors of size, rating, material, and type as indicated for each service. Where not indicated, provide proper selection as determined by installer to comply with installation requirements and with NEC standards, from only following types and conductors:
 - a. Type THHN/THWN, 600 Volt, 75/90 Degrees C Rated with Nylon Jacket: Stranded copper for all sizes.
 - b. Bare Conductors: Stranded copper for all sizes.
- C. Control Cable: No. 14 AWG minimum, type THHN/THWN, plenum rated.
- D. Power Wiring Cable Accessories: For Connectors:
 - 1. Wing nuts by Ideal.
 - 2. Stan-Kon by Thomas & Betts.
 - 3. Scotchlox Spring by Minnesota Mining & Manufacturing Company.
 - 4. Compression Type 53200 by Thomas & Betts.
 - 5. Hydent by Burndy.
 - 6. Insulated multi-cable mechanical connector blocks by Polaris, or Ilsco.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Install electrical conductors, cables, and connectors as indicated on the Drawings, in accordance with the Manufacturer's written instructions, the applicable requirements of NEC and the National Electrical Contractors Association's "Standard of Installation" and in accordance with recognized industry practices to ensure that products serve the intended functions.
 - 2. Conductors and cables shall be sized in accordance with the Drawings or, in the absence thereof, in accordance with NEC requirements. Except and indicated herein, conductor sizes greater than No. 12 AWG are indicated on the Drawings.
 - 3. Provide dedicated ungrounded conductor (neutral) for each 20A, 120V circuit.
- B. Voltage Drop Compensation:
 - 1. Provide No. 10 AWG conductors in lieu of No. 12 AWG conductors to compensate for voltage drop as follows:
 - a. For each 277V, 20 ampere branch circuit that exceeds 200 feet in length between the branch circuit panelboard and the last outlet.
 - b. For each 120V, 20 ampere branch circuit that exceeds 100 feet in length between the branch circuit panelboard and the last outlet.
 - 2. When conductor size is increased to compensate for voltage drop, provide equipment grounding conductor increased in size in accordance with NEC.
- C. Installation Procedures:
 - 1. Install interior conductors after building is enclosed and water tight.
 - 2. Each conduit shall be free of moisture and debris before conductors are installed.
 - 3. Remove moisture from conduits by swabbing.
 - 4. Install conductors so insulation is not damaged. Replace all conductors that are damaged.

5. Install conductors and cables only in code conforming raceway.
6. Pull conductors together where more than 1 conductor is being installed in a raceway.
7. Use heat shrink tubing for all instrument signal cable terminations.
8. Use manufacturer-approved pulling compound or lubricant, where necessary. Compound shall not deteriorate conductor and insulation. Compounds shall be UL listed.
9. Use a pulling means, including fish tape, cable or rope, and basket-weave wire/cable grips, that will not damage the raceway or the wire.
10. Keep conductor splices to a minimum.
11. Install splices and taps which have equivalent or better mechanical strength and insulation as the conductor.
12. Use splice and tap connectors which are compatible with the conductor material.
13. Make all joints, splices, and connections only at accessible junction or outlet boxes, never inside conduit or fitting. Make splices in No. 10 AWG and smaller wire with insulated spiral mechanical connectors.
14. Make splices in No. 8 AWG and larger copper wire with compression type mechanical connectors.
15. All splices located in handholes and wet locations shall be rated for wet locations.
16. Insulate all joints at splices with "Scotch" brand electrical pressure sensitive tape to 150% of conductor insulation value.
17. Make conductor length for parallel feeds identical.
18. Where exposed cables are installed, cables shall be installed parallel and perpendicular to exposed structural members and building lines.
19. Do not lace, strap or tie feeder or branch circuit conductors together in panels, switchboards, variable speed drives, motor control centers, automatic transfer switches, boxes, and wireways.
20. Feeders and service entrance conductors entering electrical equipment shall be adequately secured with cable cleats.
21. Use color coded conductors as follows:
 - a. Phases: Black-red-blue (under 150V to ground).
 - b. Phases: Brown-orange-yellow (over 150V to ground).
 - c. Neutral: White identified (feeders); White (branch circuits).
 - d. Ground: Green identified (feeders); Green (branch circuits).
22. Support conductors in vertical raceways in accordance Division 26 Section "Hangers and Supports for Electrical Systems."
23. Outlets:
 - a. Leave at least 6 inches of free conductor at all outlets except where conductors are intended to loop without joints through outlets for fixtures or wiring device hook-ups.
 - b. Free ends and loops at boxes and enclosures shall be pushed back into boxes and protected by blank cover plates or other means until interior painting and decorating work is completed.
24. Lights and outlets shall be grouped on circuits as indicated on the Drawings. Different types of circuits such as feeders, branch circuits, control circuits, and signal circuits, shall not be mixed in common conduit runs, but shall be run separately, although more than 1 circuit of the same system may be run in common conduit runs.

3.2 FIELD QUALITY CONTROL

A. General:

1. Prior to energization, check conductors and cables for continuity of circuitry and for short circuits. Correct malfunctions when detected.
2. Subsequent to conductor and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements.

END OF SECTION 26 05 20

SECTION 26 05 27 – GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of a complete and continuous grounding system.

1.3 DESIGN AND PERFORMANCE REQUIREMENTS

- A. All equipment, raceway systems, interior wiring systems with neutrals, receptacles, and power outlets, motors and motorized equipment shall be grounded.

1.4 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design.
- B. Grounding system shall be in accordance with the current National Electrical Code.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: A portion of the required materials for grounding systems are specified in the Division 26 – Electrical Sections.

PART 3 - EXECUTION

3.1 DISTRIBUTION SYSTEM GROUNDING

- A. Circuit Grounding: Install grounding bushings, grounding studs, and grounding jumpers at distribution centers, pull boxes, and panelboards.
- B. Bonding Jumpers:
 - 1. Provide green insulation, size correlated with overcurrent device protecting the wire, attached to grounding bushings on conduits, to lugs on boxes, and other enclosures.
 - 2. Bond to neutral only at service neutral bar.
- C. FMC and LTFMC: Install separate grounding conductor in FMC and LTFMC. Connect each end to a grounding bushing.
- D. Receptacles and Power Outlets: Ground receptacles and power outlets to the conduit system with a Type THHN green grounding conductor sized in accordance with NEC Article 250 and connected between the device grounding screw and outlet box.
- E. Metallic Conduit: When grounding conductors are enclosed in metallic conduit, the conduit shall be bonded to the grounding conductors at both ends.

- F. Ground motor bases and frames by pulling a separate conductor in with the motor feeder.
- G. Expansion Joints: Install a bonding jumper around expansion fittings in metallic conduit to maintain ground continuity.
- H. Separately Derived Systems: Grounding of separately derived systems, i.e., secondary transformers, shall be in accordance with NEC, Article 250. Use suitable ground lugs and clamps approved for this purpose.

END OF SECTION 26 05 27

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of the following:
 - 1. Hangers and supports for electrical equipment and systems.

1.3 DEFINITIONS

- A. Electrical Supports: Angles, channels, brackets, and mounting accessories for supporting all conduit, luminaires, switches, and other electrical equipment which are hung or mounted above floor.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

- A. This Section defines general criteria for the selection and installation of supporting devices, but does not cover all types specifically required for the Project.
- B. Choose or design supporting devices in accordance with these general criteria.

1.5 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed submittals.
- B. Regulatory Agencies Requirements:
 - 1. Provide supporting devices listed by Underwriters' Laboratory for their application as installed.
 - 2. Comply with National Electrical Code (NFPA 70) as applicable to construction, installation, and requirements for supporting devices.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Conduit Supports:
 - 1. Single Runs: Galvanized conduit straps or ring bolt type hangers with spring clips. Do not use plumber's perforated straps.
 - 2. Use fiberglass supports in the mechanical room areas. Hardware used in the mechanical rooms shall be stainless steel.
 - 3. Multiple Runs: Conduit rack with 25% spare capacity.
 - 4. Vertical Runs: Channel support with conduit fittings.
 - 5. Manufacturers:
 - a. Cooper B-Line; a division of Cooper Industries
 - b. ERICO International Corporation.
 - c. Allied Support Systems; Power-Strut Unit.
 - d. GS Metals Corp.
 - e. Michigan Hanger Co., Inc.; O-Strut Div.
 - f. National Pipe Hanger Corp.
 - g. Thomas & Betts Corporation.
 - h. Unistrut; Tyco International, Ltd.
 - i. Wesanco, Inc.
 - j. Or equal.
- B. Mounting, Anchoring, and Attachment Components
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 3. Manufacturers:
 - a. Hilti, Inc.
 - b. ITW Construction Products.
 - c. MKT Fastening, LLC.
- C. Supports for Conductors in Vertical Conduit:
 - 1. Install in compliance with NEC article 300.19.
 - 2. Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Layout to maintain headroom, neat mechanical appearance, and to support equipment loads.
 - 2. Secure Engineer's approval before welding or bolting to steel framing or anchoring to concrete structure.
 - 3. Where equipment is to be suspended from cast-in-place concrete construction, set approved concrete inserts in formwork to receive hanger rods. Where equipment is to be suspended from metal deck and beam or joist construction, support equipment from beams or joists only.

END OF SECTION 26 05 29

SECTION 26 05 34 – RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of conduits and fittings for electrical wiring.

1.3 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design.
- B. Regulatory Agencies Requirements:
 - 1. ACI – American Concrete Institute – Standards pertaining to conduits embedded in concrete (Section 6.3 in ACI 318 – Building Code Requirements for Structural Concrete and Section 6.3 in ACI 350R – Environmental Engineering Concrete Structures.)
 - 2. NEMA – National Electrical Manufacturer's Association – Standards pertaining to raceways.
 - 3. NEC – National Electric Code – As applicable to construction and installation of conduit system.
 - 4. Provide conduit which is listed and labeled by Underwriters' Laboratories.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage (e.g., bending, end damage, finish scoring), contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping. Provide color coded end cap thread protectors on exposed threads of threaded metal conduit.
- D. Reject damaged, deteriorated, or contaminated material and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Rigid Steel Conduit (RSC): Galvanized steel, heavy wall conduit with threaded fittings, 1/2-inch trade size minimum, insulated bushings.
- B. Electrical Metallic Tubing (EMT):
 - 1. Thin wall, hot galvanized, steel tubing, 3/4-inch trade size minimum with insulated throat steel connector.
 - 2. Fittings: Steel Compression (die cast fittings are expressly prohibited).
- C. Liquid Tight Flexible Metal Conduit (LTFMC): 1/2-inch trade size minimum with galvanized steel flexible conduit with flexible, moisture-proof PVC jacket and liquid tight connectors.
 - 1. In the mechanical room areas, LTFMC fittings shall be PVC coated.

- D. Conduit Hubs for RSC:
 - 1. Suitable for environment served.
 - 2. Grounding screw.
 - 3. O-ring gasket.
 - 4. Material: stainless steel Type 316.
 - 5. Manufacturer:
 - a. Cooper Myers Hubs.
 - b. Thomas & Betts.
 - c. Killark.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Exposed conduit shall be permitted.
- B. Install conduit products in accordance with:
 - 1. The Manufacturer's written instructions.
 - 2. Applicable requirements of NEC and National Electrical Contractors Association's "Standard of Installation."
 - 3. Recognized industry practices to ensure that products serve intended function.
- C. Conduit Joints: Cut square, reamed smooth and drawn up tight.
- D. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joint. Follow compound manufacturer's written instructions.
- E. Bends:
 - 1. Number per run for conduit that support feeder and branch circuits: Do not exceed the equivalent of 4 quarter bends (360 degrees) between pull points.
 - 2. Number per run for conduit that supports data/communications cabling: Do not exceed the equivalent of 2 quarter bends (180 degrees) between pull points.
 - 3. Make bends and offsets so as not to reduce the inner diameter of the conduit.
 - 4. To the extent possible, avoid using large junction boxes as 90 degree junctions.
- F. Routing:
 - 1. Concealed Conduits: Run in a direct line with long sweep bends and offsets.
 - 2. Exposed Conduits: Run parallel to, and at right angles to, building lines.
 - 3. Run continuous from outlet to outlet and from outlets to cabinets, pull or junction boxes.
 - 4. Secure to all boxes and cabinets with locknuts and bushings in such a manner that each system is electrically continuous throughout.
- G. Cap conduit ends to prevent entrance of foreign materials during construction.
- H. Provide insulated bushings on all threaded conduit run terminations and where entering the bottom of open-bottom switchboards, transformers, and similar equipment.
- I. Where entering the bottom of open-bottom equipment (i.e., switchboards, panelboards, transformers, and similar equipment) conduit shall not be installed flush with the floor/equipment pad and shall not rise more than 3 inches above the bottom of the enclosure.
- J. Conduit entering control panels shall not obstruct internal components and shall allow for neat and workmanlike wire management.
- K. Completely install all conduit systems before installing conductors.

- L. Support:
 - 1. Adequately support conduit from structural elements of the building.
 - 2. Do not drill or tap structural building steel without approval from Engineer.
 - 3. Do not rest conduit on, nor support it from, ceiling suspension systems, ceiling tiles or mechanical equipment including, but not necessarily limited to ductwork and fans.
 - 4. Conduit shall be supported in accordance with the NEC and Division 26 Section "Hangers and Supports for Electrical Systems."
- M. Provide conduit expansion couplings where conduits cross building or structure expansion joints.
- N. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200 pound (90 kg) tensile strength. Label and leave at least 12 inches of slack at each end of pull wire.
- O. LTFMC Installation:
 - 1. Provide separate grounding conductor in accordance with Division 26 Section "Grounding and Bonding."
 - 2. Connection to light fixtures shall not exceed 6 feet in length within an accessible ceiling and 3 feet in length where exposed. Connection to solenoids, pressure switches, motors, fans, HVAC equipment, and similar equipment shall not exceed 3 feet in length.

3.2 CONDUIT SCHEDULE

- A. Feeders, Branch Circuits and System Conduits:
 - 1. Above Slab or Grade:
 - a. Exposed Conduit Below 10'-0" AFF: RSC or IMC where subject to physical damage. EMT where not subject to physical damage.
 - b. Exposed Conduit Above 10'-0" AFF: EMT.
 - c. Concealed in Walls: EMT or FMC.
 - d. Concealed Above Ceiling: EMT.
- B. Connection to Equipment:
 - 1. Vibrating Equipment (including, but not necessarily limited to motors and transformers):
 - a. Motors:
 - 1) Dry Locations: FMC.
 - 2) Wet or Damp Locations: LTFMC.
 - 3) Corrosive Locations (Mechanical Rooms): LTFMC with PVC coated fittings.
 - b. Transformers at Dry Locations: FMC.
- C. Provide separate raceway systems for:
 - 1. Normal power wiring.
 - 2. Low voltage signal and control wiring.

END OF SECTION 26 05 34

SECTION 26 05 35 – BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of all electrical boxes and the major items listed below:
 - 1. Outlet boxes.
 - 2. Junction boxes.
 - 3. Pull boxes.

1.3 REFERENCES

- A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
 - 1. NEMA - National Electrical Manufacturer's Association: Standards as applicable to nonmetallic fittings for underground installation.
 - 2. NECA - National Electrical Contractor's Association's: Applicable portions of "Standard of Installation".

1.4 QUALITY ASSURANCE

- A. Fabrication and Installation Personnel Qualifications:
 - 1. Trained and experienced in the fabrication and installation of the materials and equipment.
 - 2. Knowledgeable of the design and the reviewed submittals.
- B. Regulatory Agencies Requirements:
 - 1. Provide boxes which are listed and labeled by Underwriters' Laboratories.
 - 2. NEC - National Electrical Code (NFPA 70) - As applicable to construction and installation of electrical boxes.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver all materials in original, unbroken, brand marked containers or wrapping as applicable.
- B. Handle and store materials in a manner which will prevent deterioration or damage, contamination with foreign matter, damage by weather or elements, and in accordance with Manufacturer's directions.
- C. Store materials indoors and protect from weather. When necessary to store outdoors, elevate materials above grade and enclose with durable, watertight wrapping.
- D. Reject damaged, deteriorated, or contaminated materials and immediately remove from the Site. Replace rejected materials with new materials at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Interior Outlet Boxes:
 - 1. Galvanized steel outlet boxes of the type, shape, and size, including depth of box, to suit each respective location and installation; constructed with stamped knockouts in back and sides, and with threaded holes with screws for securing box covers or wiring devices.
 - 2. In areas requiring exposed RNMC, provide nonmetallic outlet boxes of type, shape and size to suit each location. Each box is to have conduit hubs with removable plugs and a non-metallic cover. Each box shall be compatible with RNMC.
- B. Interior Outlet Box Accessories:
 - 1. As required for each installation, including mounting brackets, wallboard hangers, extension rings, fixture studs, cable clamps, and metal straps for supporting outlet boxes. Accessories shall be compatible with outlet boxes being used and meet the requirements of individual wiring situations.
 - 2. Choice of accessories is installer's option.
- C. Surface Mounted: 4-inch square.
- D. Junction and Pull Boxes: Sheet steel junction and pull boxes, with screw-on covers; of the type and shape and size to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers. Dry interior location boxes shall have baked enamel finish. Damp location and exterior boxes shall have galvanized finish.
- E. Flush Mounted Pull Boxes: Provide overlapping covers with flush-head cover retaining screws, prime coated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Install electrical boxes as indicated, in compliance with NEC requirements and in accordance with the Manufacturer's written instructions and recognized industry practices to ensure that the boxes and fittings serve the intended purposes.
 - 2. Provide knockout closures to cap unused knockout holes where blanks have been removed.
 - 3. Locate boxes and conduit bodies so as to ensure accessibility of electrical wiring.
 - 4. Secure boxes rigidly to the substrate upon which they are being mounted, or solidly embed boxes in concrete or masonry.
 - 5. Mount outlet boxes flush in areas other than mechanical rooms, electrical rooms, and above removable ceilings.
 - 6. Do not use sectional or handy boxes unless specifically requested.
 - 7. For boxes mounted in exterior walls install insulation behind outlet boxes to prevent condensation in boxes.
 - 8. Locate pull boxes and junction boxes above removable ceilings or in electrical rooms, utility rooms, or storage areas such that boxes will be accessible after completion of building.
 - 9. All boxes shall have covers installed at completion of construction.

END OF SECTION 26 05 35

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the furnishing and installation of proper identification for electrical system components.
- B. Items requiring identification or labeling include:
 - 1. Cables and conductors.
 - 2. Conduit systems.
 - 3. Distribution Equipment:
 - a. Disconnect switches.
 - b. Enclosed circuit breakers.

1.3 SUBMITTALS

- A. Nameplate schedule identifying each device to be labeled and project specific label text.

PART 2 - PRODUCTS

2.1 ELECTRICAL LABELS

- A. Provide engraved laminated plastic nameplate to identify each piece of electrical equipment:
 - 1. Nameplate shall have 3/8-inch minimum black letters on a white background.
 - 2. Punched or drilled for mechanical fasteners.
- B. Provide printed labels by Brady or T&B to identify conductors.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Attach nameplates directly to each piece of electrical equipment. In finished areas of building, install nameplates behind enclosure door where possible.
 - 2. Where several conductors pass through a pull box, junction box, or enclosure, provide wire labels. Group wires before labeling.
- B. Cables and Conductors: In accordance with Division 26 Section "Conductors and Cables – 600V and Below."
- C. Conduit Systems:
 - 1. Junction boxes used for fire alarm system wiring shall be red.
 - 2. Provide label inside each junction and pull box identifying circuit numbers for all conductors contained inside the box. Labeling shall be printed neatly with permanent, waterproof, black ink marker.
- D. Controls: For each of the following control devices, provide label attached to enclosure cover. Label shall identify:
 - 1. Motor Starters: Name of equipment served and load (example, "EF-5, 5 HP").
 - 2. Variable Frequency Drives: Name of equipment served and load (example, "P-1, 25 HP").

- E. Distribution Equipment: For each of the following pieces of distribution equipment, provide label attached to enclosure cover. Label shall identify:
1. Disconnect Switches: Name of equipment served, number of poles, ampere rating/fuse size (where applicable), and load (example, "RTU-1, 3P30/25, 8 TON").
 2. Enclosed Circuit Breakers: Name of device as indicated on one line diagram, number of poles, and circuit breaker size (example, "MCB, 3P200").

END OF SECTION 26 05 53

SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Division 01 Specification Sections, apply to this Section. Refer to Division 01 Section "General Commissioning Requirements" for detailed explanation of commissioning work. Section also contains sample Cx Plan, construction checklist, and functional test.

1.2 SUMMARY

- A. This Section lists electrical systems to be commissioned. The commissioning process is described in detail in the commissioning plan (Refer to Division 01 Section "General Commissioning Requirements").

1.3 SYSTEMS TO BE COMMISSIONED

- A. The following systems will be commissioned:
 - 1. Conductors and Cables 600V and below.
 - 2. Grounding and Bonding.
 - 3. Low Voltage Circuit Protective Devices.
 - 4. Boiler Shut Down Controls.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION 26 08 00

Wayne State University

Pharmacy School Building Additional Boiler Capacity 259 Mack Ave., Detroit, MI 48201 WSU#603-312827

Issued for Bids and Construction February 11, 2019
Project Number 180929



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BUILDING CODE INFORMATION



WAYNE STATE
UNIVERSITY

ftc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.
www.ftch.com

Wayne State University

259 Mack Ave., Detroit, MI 48201

Pharmacy School Building Additional Boiler Capacity
WSU Project: 603-312827

REVISIONS

2/11/2019 | BIDS AND CONSTRUCTION

Drawn By CEB
Designer PMO
Reviewer GDM
Manager PMO

Hard copy is intended to be 24"x36" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

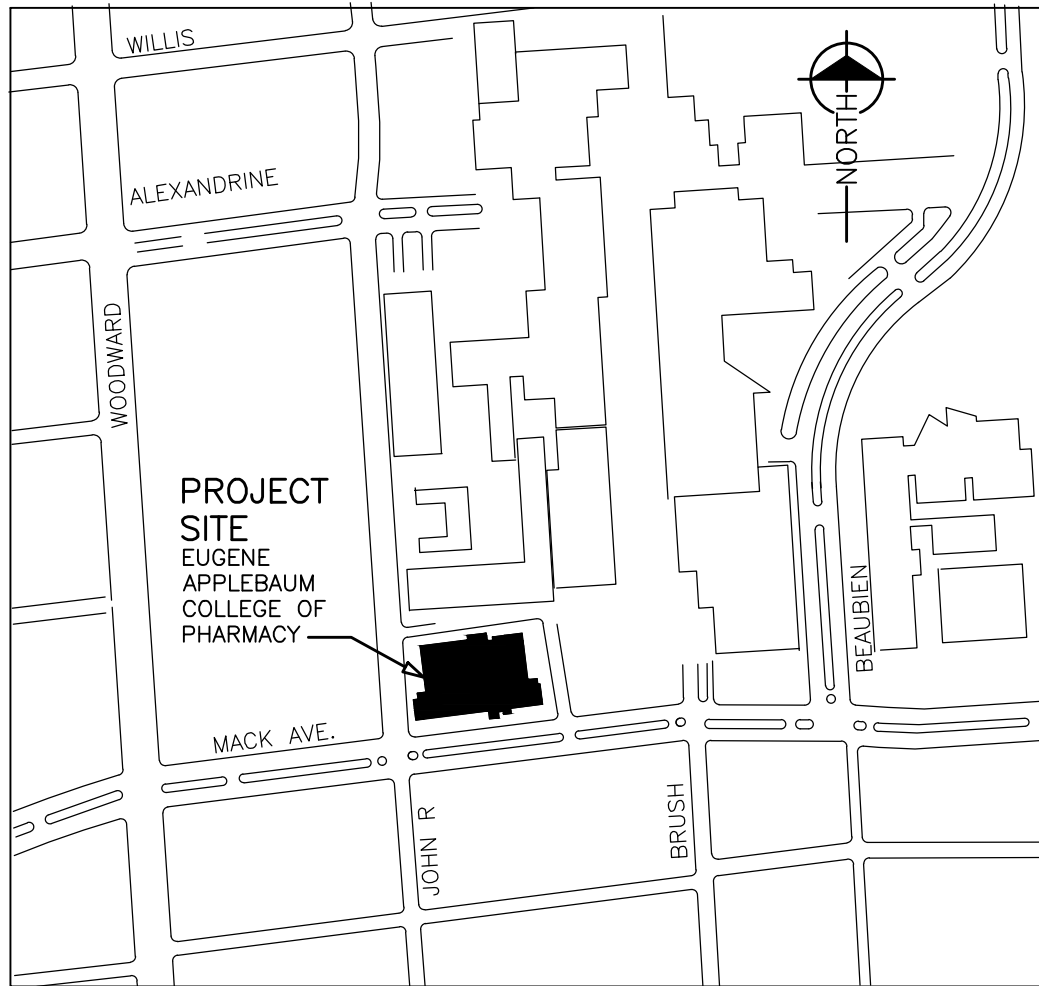
PROJECT NO.
180929

SHEET NO.

T001

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LOCATION MAP



SEAL

GENERAL ABBREVIATIONS

| | | | | | | | |
|--------|-----------------------|--------|-------------------------|-------|-----------------------------|-------|--------------------------|
| AFF | ABOVE FINISH FLOOR | FD | FLOOR DRAIN | MEZZ. | MEZZANINE | RD | ROOF DRAIN |
| AHU | AIR HANDLING UNIT | FRT | FIRE RETARDANT TREATED | MIN. | MINIMUM | RO | ROUGH OPENING |
| AL. | ALUMINUM | FT. | FOOT/FEET | MO. | MASONRY OPENING | SCH. | SCHEDULE |
| ALT. | ALTERNATE | GA. | GAUGE/GAGE | MTD. | MOUNTED | SF | SQUARE FOOT |
| BF. | BARRIER FREE | GALV. | GALVANIZED | N/A | NOT APPLICABLE | SIM. | SIMILAR |
| BRG. | BEARING | GC | GENERAL CONTRACTOR | NC | NOISE CRITERIA | SP. | SPACE/SPACING |
| CJ | CONTROL JOINT | HB | HOSE BIBB | NIC | NOT IN CONTRACT | SQ. | SQUARE |
| CL. | CENTERLINE | HP | HIGH POINT | NO. | NUMBER | SS | STAINLESS STEEL |
| CLG. | CEILING | HORIZ. | HORIZONTAL | NRC | NOISE REDUCTION COEFFICIENT | STD. | STANDARD |
| CMU | CONCRETE MASONRY UNIT | HVAC | HEATING VENTILATING AIR | NTS | NOT TO SCALE | TAN. | TANGENT |
| CO. | CLEANOUT | COND. | CONDITIONING | OC | ON CENTER | TYP. | TYPICAL |
| CONC. | CONCRETE | ID | INSIDE DIAMETER | OD | OUTSIDE DIAMETER | UL. | UNDERWRITER'S LABORATORY |
| CONST. | CONSTRUCTION | IE | INVERT ELEVATION | OH. | OVERHEAD | UNO | UNLESS NOTED OTHERWISE |
| CONT. | CONTINUOUS | IN. | INCH/INCHES | OPP. | OPPOSITE | VERT. | VERTICAL |
| DIA. | DIAMETER | INSUL. | INSULATION | ORD | OVERFLOW ROOF DRAIN | VTR | VENT THROUGH ROOF |
| DN. | DOWN | LAV. | LAVATORY | PERP. | PERPENDICULAR | W/ | WITH |
| DS. | DOWNSPOUT | LED | LIGHT EMITTING DIODE | PL. | PLATE | WC | WATER CLOSET |
| EF | EXHAUST FAN | LLH | LONG LEG HORIZONTAL | PSF | POUNDS PER SQUARE FOOT | WH | WATER HEATER |
| EL. | ELEVATION | LLV | LONG LEG VERTICAL | PSI | POUNDS PER SQUARE INCH | W/O | WITHOUT |
| EJ | EXPANSION JOINT | LP | LOW POINT | PVC | POLYVINYL CHLORIDE | WP. | WEATHERPROOF |
| EQ. | EQUAL | MFR. | MANUFACTURER | R | RADIUS | WT. | WEIGHT |
| EW | ELECTRIC WATER COOLER | MAX. | MAXIMUM | REQD. | REQUIRED | | |

GRAPHIC SYMBOLS

| | |
|-------------------------|------------------|
| SECTION CUT LINE | |
| 1 A501 | |
| NORTH ARROW DESIGNATION | |
| NORTH | |
| ROOM NAME AND NUMBER | VESTIBULE 101 |
| DOOR NUMBER | 101 |

| |
|---|
| ELEVATION, SECTION AND DETAIL DESIGNATION |
| 1 SECTION |
| SCALE: 3/4" = 1'-0" |
| PLAN DESIGNATION |
| FLOOR PLAN |
| SCALE: 1/8" = 1'-0" |

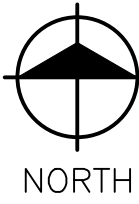
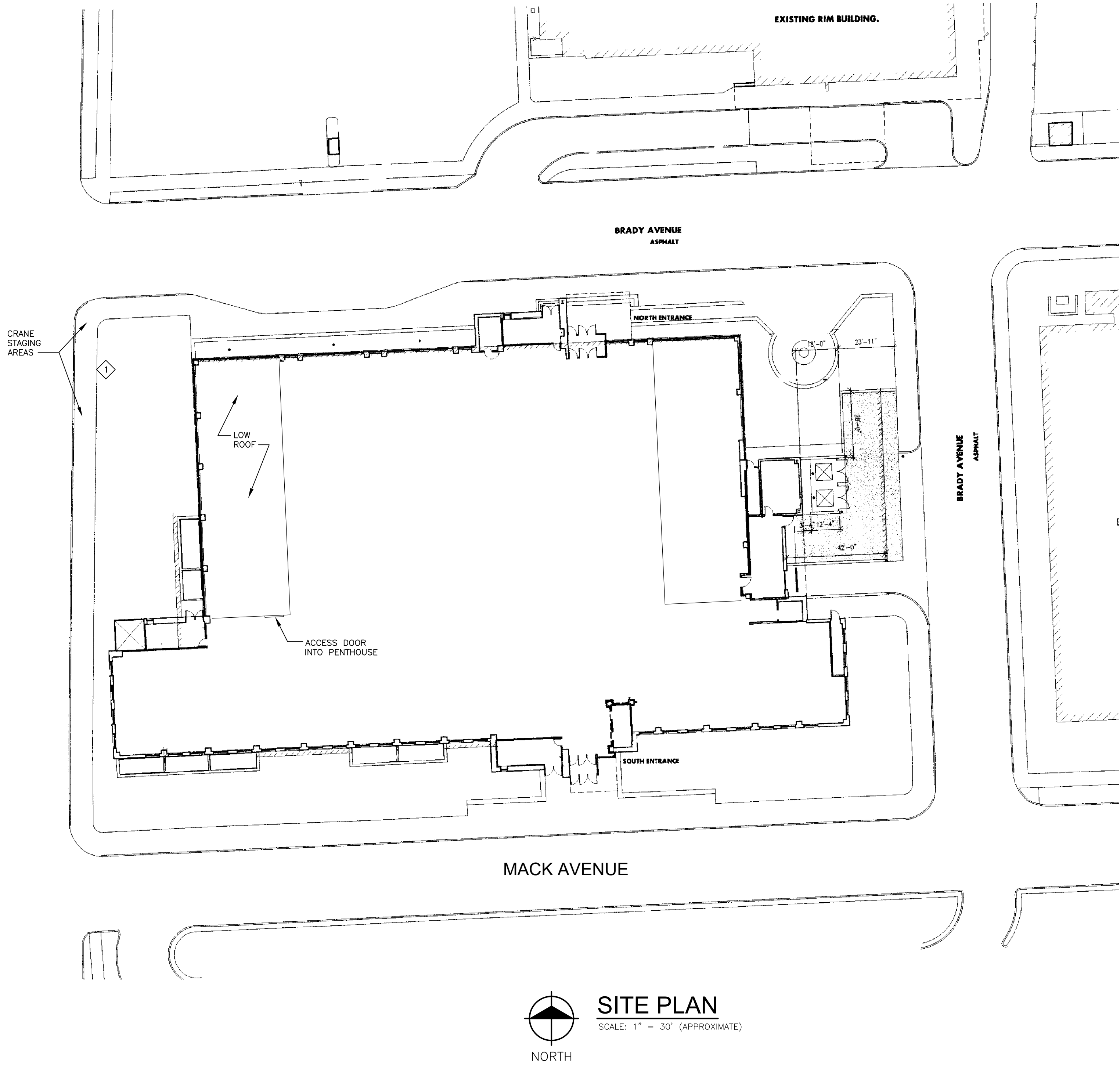
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|------------------|-----------------------------|
| ELEVATION TARGET | |
| ELEVATION TAG | FINISH FLOOR EL. 100'-0" |

| |
|------------------------|
| EXTERIOR ELEVATION TAG |
| A A001 |
| INTERIOR ELEVATION TAG |
| A C A301 D B |

| | |
|-----------------------|-----------|
| ENLARGED DETAIL FRAME | 1 A201 |
| WALL TYPE TAG | F1 |
| SIGNAGE TAG | 1 |
| FINISH TAG | P-1 |

| | |
|-------------------------|----|
| BULLETIN IDENTIFICATION | B1 |
| ADDENDUM IDENTIFICATION | A1 |
| SKETCH IDENTIFICATION | S1 |
| BARRIER FREE LOCATION | |
| KEY NOTE TAG | 1 |
| DEMOLITION NOTE TAG | 1 |

JOHN R STREET



SITE PLAN

SCALE: 1" = 30' (APPROXIMATE)

NOTES

- CONTRACTOR TO DETERMINE MEANS FOR RIGGING MATERIALS AND EQUIPMENT TO THE PENTHOUSE MECHANICAL ROOM. CONTRACTOR SHALL SUBMIT A PLAN INCLUDING ANY POTENTIAL STREET CLOSURES WITH THEIR BID.
- THE EXISTING SITE AND BUILDING SHALL BE PROTECTED AS MUCH AS POSSIBLE DURING CONSTRUCTION. CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIRING SITE AND BUILDING ITEMS BACK TO PRE-CONSTRUCTION CONDITIONS IF DAMAGE OCCURS DURING CONSTRUCTIONS.
- EXISTING FIRE DEPARTMENT ACCESS MUST BE MAINTAINED DURING CONSTRUCTION.

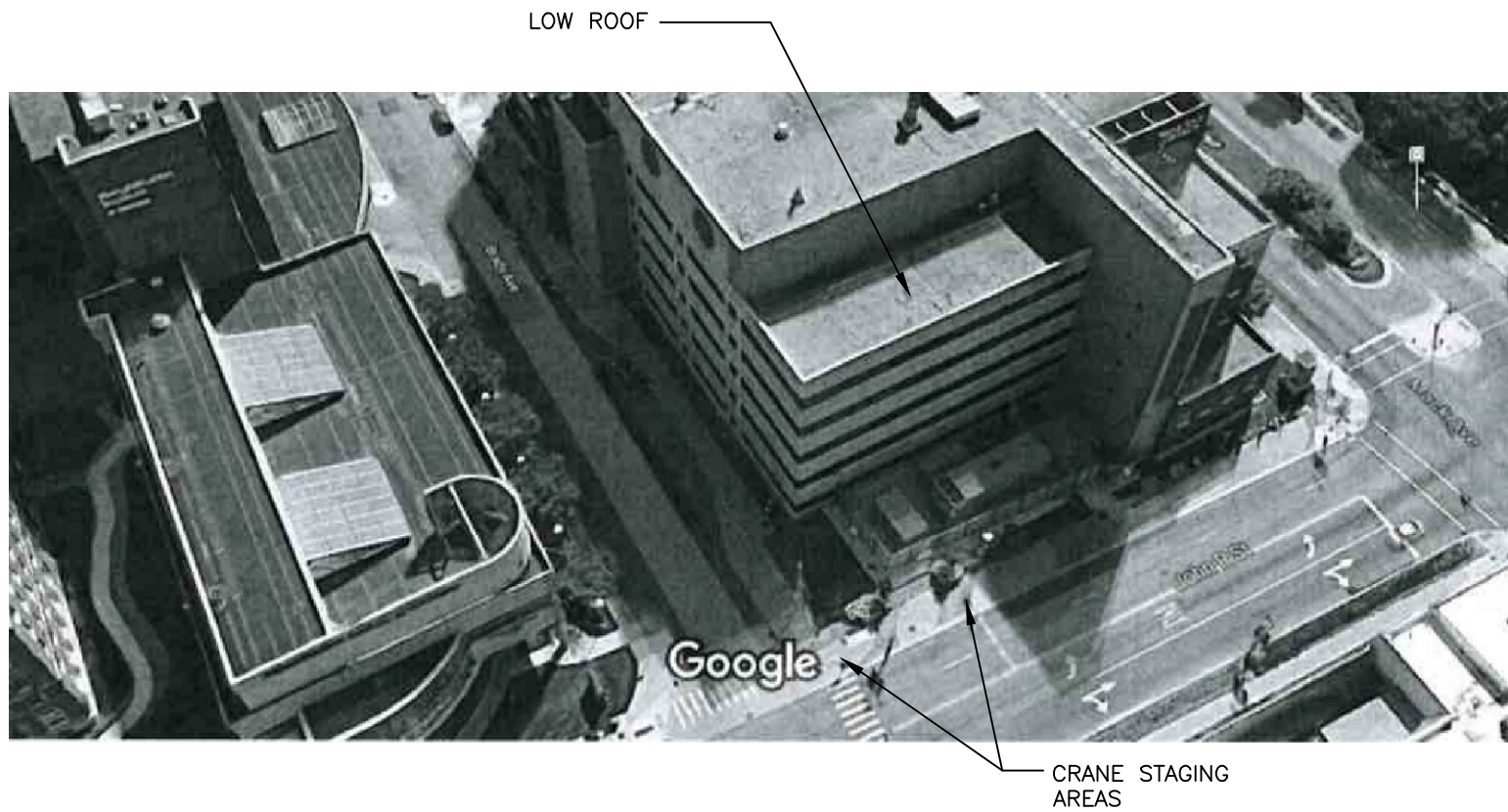
KEY NOTES

- POTENTIAL CRANE STAGING AREA FOR CONTRACTOR. CONTRACTOR TO DETERMINE BEST MEANS FOR RIGGING EQUIPMENT AND MATERIALS TO MEET PROJECT REQUIREMENTS. COORDINATE STAGING, DELIVERY, RIGGING WITH EQUIPMENT MANUFACTURER AND UNIVERSITY. ALL EXISTING BUILDING MEANS OF EGRESS AND ACCESS MUST BE MAINTAINED AND THE CONTRACTOR IS RESPONSIBLE FOR PROVIDING ALL NECESSARY TEMPORARY FENCING, WALKWAY COVERS, ETC. AS REQUIRED. EQUIPMENT LIFTS MUST BE COORDINATED WITH THE UNIVERSITY.

GENERAL NOTES

HVAC PIPING NOTES

- THE INSTALLATION OF ALL PIPING SHALL BE CLOSELY COORDINATED WITH EXISTING SHEET METAL, PLUMBING, ELECTRICAL, AND STRUCTURAL CONDITIONS. NOT ALL REQUIRED OFFSETS AND FITTINGS ARE INDICATED, BUT SHALL BE PROVIDED. COORDINATE TIME OF EXISTING PIPING REROUTING WITH OWNER TO MINIMIZE DOWNTIME.
- ALL EXISTING DUCTWORK, PIPING, AND CONDUIT HANGERS THAT ARE IN CONFLICT WITH NEW PIPING SHALL BE RELOCATED.
- DUCT, PIPING AND EQUIPMENT SHOWN LIGHTLY IS EXISTING TO REMAIN.
- THE INDICATED ROUTING OF PIPING SYSTEMS IS INTENDED TO INDICATE REUSE OF AS MUCH OF THE EXISTING SYSTEMS AS POSSIBLE. THE ROUTE SHOWN AND INFORMATION GIVEN IS NOT INTENDED TO REPRESENT EXACTLY WHERE AND HOW TO INSTALL THESE SYSTEMS. IT HAS BEEN DETERMINED THAT ADEQUATE SPACE EXISTS BUT NO ATTEMPT HAS BEEN MADE TO INDICATE THE LOCATION AND IDENTITY OF EVERY INTERFERENCE. NOR THE RESULTANT REQUIRED RESOLUTION OF INTERFERENCES. ADDITIONAL PIPE, MATERIAL, LABOR AND LAYOUT TIME REQUIRED TO RESOLVE INTERFERENCES AND THEIR REROUTING SHALL BE INCLUDED.
- UNLESS OTHERWISE NOTED, ALL CONDENSATE PIPE SHALL BE FULL SIZE OF ASSOCIATED STEAM TRAP CONNECTION. MINIMUM CONDENSATE PIPE SIZE SHALL BE 3/4-INCH.
- PIPE ANCHORS, EXPANSION LOOPS, AND JOINTS AND GUIDES SHALL BE PROVIDED AS REQUIRED. REFER TO SPECIFICATIONS.
- SLEEVE AND SEAL EXTERIOR ROOF PENETRATIONS TO A WEATHER TIGHT CONDITION.
- PROVIDE ISOLATION, DRAIN AND FILLING OF EXISTING PIPING SYSTEMS AS REQUIRED TO PERFORM THE WORK.
- WHERE NEW CONNECTIONS TO EXISTING PIPE ARE INDICATED, SYSTEM SERVICE INTERRUPTION IS TO BE MINIMIZED AND COORDINATED WITH OWNER. TIE-IN METHODS TO INCLUDE HOT TAP AS REQUIRED.
- NEW PIPING SHALL NOT BE ROUTED OVER ELECTRICAL GEAR UNLESS IT MEETS THE CLEARANCE REQUIREMENTS OF THE NEC.
- VALVE INDICATIONS ARE GENERIC. REFER TO SPECIFICATION FOR ACCEPTABLE VALVE TYPES PER APPLICATION.

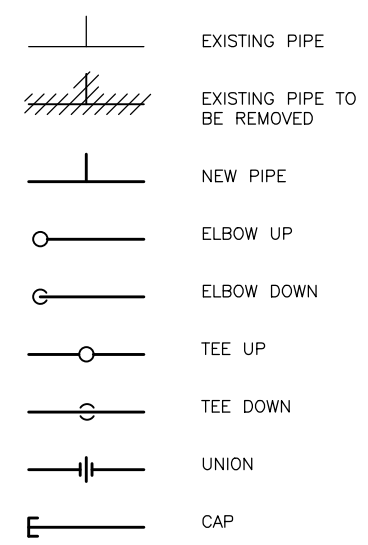


PHOTO

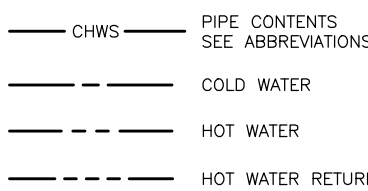
NO SCALE

LEGEND

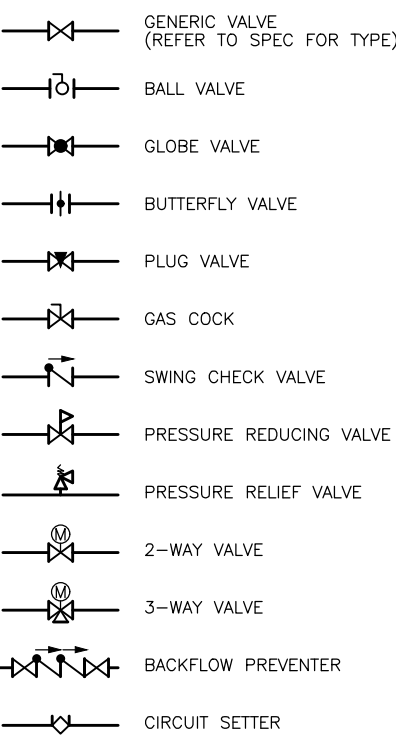
PIPE/FITTING SYMBOLS



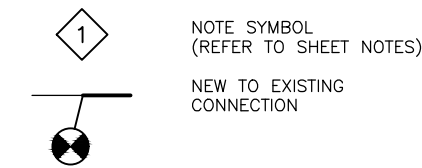
PIPING DESIGNATION



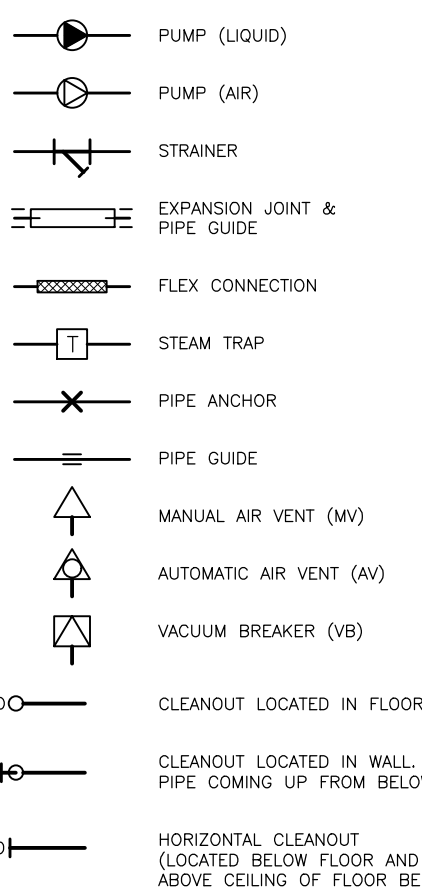
VALVE SYMBOLS



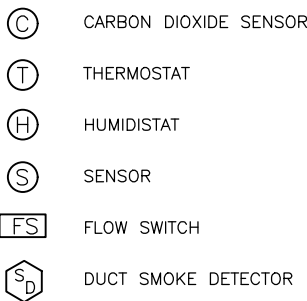
GENERAL DESIGNATION



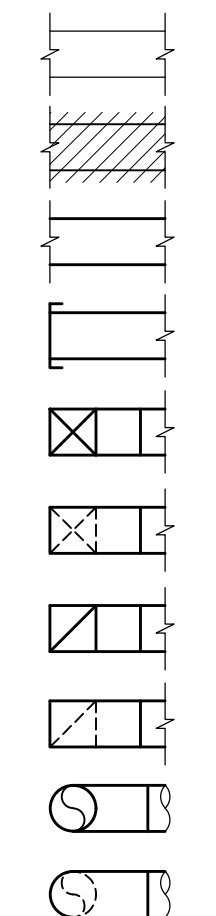
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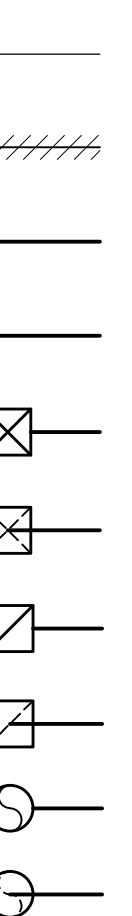
CONTROLS



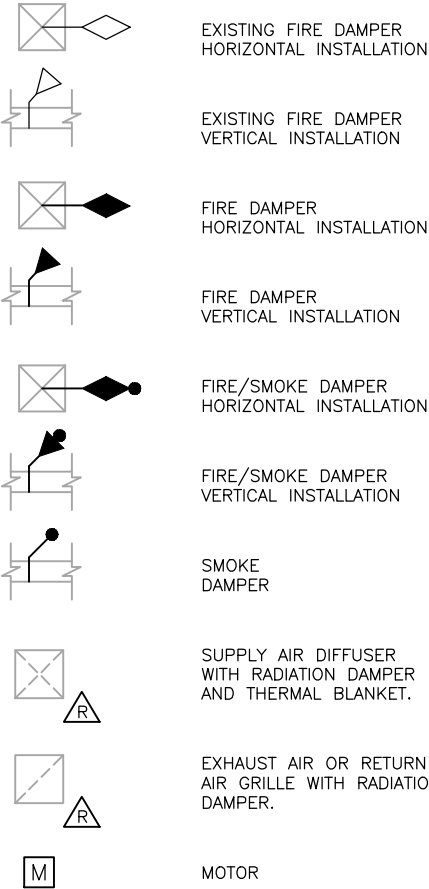
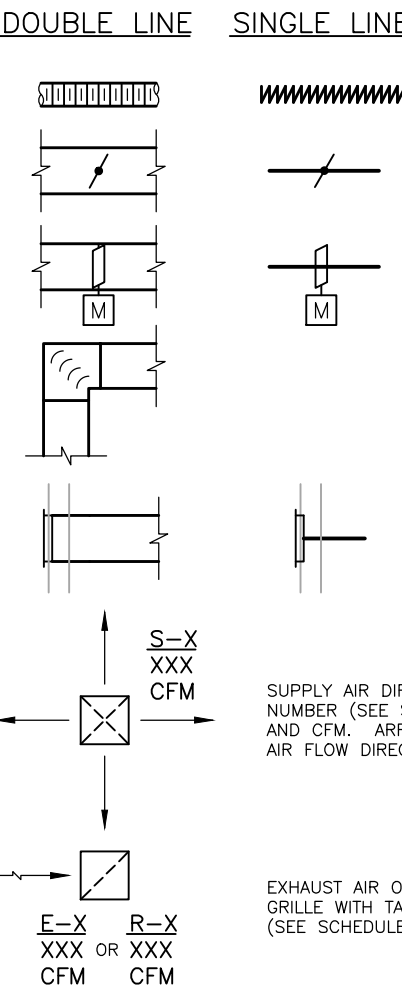
DOUBLE LINE



SINGLE LINE



HVAC DUCTWORK SYMBOLS



| GENERAL ABBREVIATIONS | | | |
|-----------------------|-----------------------|-----|---------------------|
| AFF | ABOVE FINISHED FLOOR | MD | MOTORIZED DAMPER |
| AI | ACOUSTICAL INSULATION | NC | NOT IN CONTRACT |
| AL | ACOUSTICAL LINING | OA | OUTSIDE AIR |
| AP | ACCESS PANEL | PA | RETURN AIR |
| BD | BALANCING DAMPER | RA | RETURN AIR |
| BDD | BACKDRAFT DAMPER | RC | RAIN CONDUCTOR |
| CI | CAST IRON | RD | ROOF DRAIN |
| CS | CLIMB SINK | S | SINK |
| DF | DRINKING FOUNTAIN | SA | SUPPLY AIR |
| EA | EXHAUST AIR | SP | SUPPLY FAN |
| EF | EXHAUST FAN | SS | SHOWER |
| EAG | EXHAUST AIR GRILLE | SH | SERVICE SINK |
| EM SH | EMERGENCY SHOWER | SS | SHOWER |
| EW | EYEWASH | UR | URINAL |
| DWC | ELECTRIC WATER COOLER | VAV | VARIABLE AIR VOLUME |
| FC | FLOOR CONNECTION | VIR | VIBRATION ISOLATOR |
| FD | FLOOR DRAIN | WC | WATER CLOSET |
| FS | FLOOR SINK | WC | WATER COLUMN |
| HB | HOSE BIBB | WH | WALL HYDRANT |
| IE | INVERT ELEVATION | YH | YARD HYDRANT |
| L | LOUVER | | |
| LAV | LAVATORY | | |

DETAIL OR SECTION

SCALE: SCALE OF DETAIL/SECTION
SHEET NUMBER THAT DETAIL/SECTION IS DRAWN ON

| PIPE | CONTENTS | ABBREVIATIONS |
|------|------------------------------|---------------|
| AR | ARGON GAS | |
| AV | ACID VENT | |
| AW | ACID WASTE | |
| BF | BOLTER FEED | |
| CA | CHILLED WATER RETURN | |
| CHWR | CHILLED WATER RETURN | |
| CHWS | CHILLED WATER SUPPLY | |
| COND | CONDENSATE | |
| CO2 | CARBON DIOXIDE | |
| CR | CONDENSER WATER RETURN | |
| CS | CONDENSER WATER SUPPLY | |
| CW | COLD WATER | |
| DWS | DEIONIZED WATER RETURN | |
| DWR | DEIONIZED WATER RETURN | |
| FDR | FUEL OIL RETURN | |
| FDS | FUEL OIL SUPPLY | |
| FP | FIRE PROTECTION WATER SUPPLY | |
| G | GAS SUPPLY | |
| HPS | HIGH PRESSURE STEAM | |
| HW | DOMESTIC HOT WATER | |
| HWR | DOMESTIC HOT WATER RETURN | |
| HWR | HEATING WATER RETURN | |
| HWS | HEATING WATER SUPPLY | |
| LA | LABORATORY AIR | |
| LPS | LOW PRESSURE STEAM | |
| LV | LABORATORY VACUUM | |
| MA | MEDICAL AIR | |
| MPS | MEDIUM PRESSURE STEAM | |
| N2 | NITROGEN | |
| N2O | NITROUS OXIDE | |
| NPW | NON-POTABLE WATER | |
| OK | OXYGEN | |
| PC | PUMPED CONDENSATE | |
| PHWR | PRIMARY HEATING WATER RETURN | |
| PHWS | PRIMARY HEATING WATER SUPPLY | |
| PW | POTABLE WATER | |
| ROR | REVERSE OSMOSIS WATER RETURN | |
| ROR | REVERSE OSMOSIS WATER SUPPLY | |
| ROS | REVERSE OSMOSIS WATER SUPPLY | |
| SAH | SANITARY | |
| SCW | SOFT COLD WATER | |
| SM | STEAM | |
| STM | STORM SEWER | |
| V | VACUUM | |
| V | VACUUM | |
| VWR | WELL WATER RETURN | |
| WWS | WELL WATER SUPPLY | |



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Pharmacy School Building Additional Boiler Capacity
WSU Project: 603-312827

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Drawn By CEB

Designer PMO

Reviewer GDM

Manager PMO

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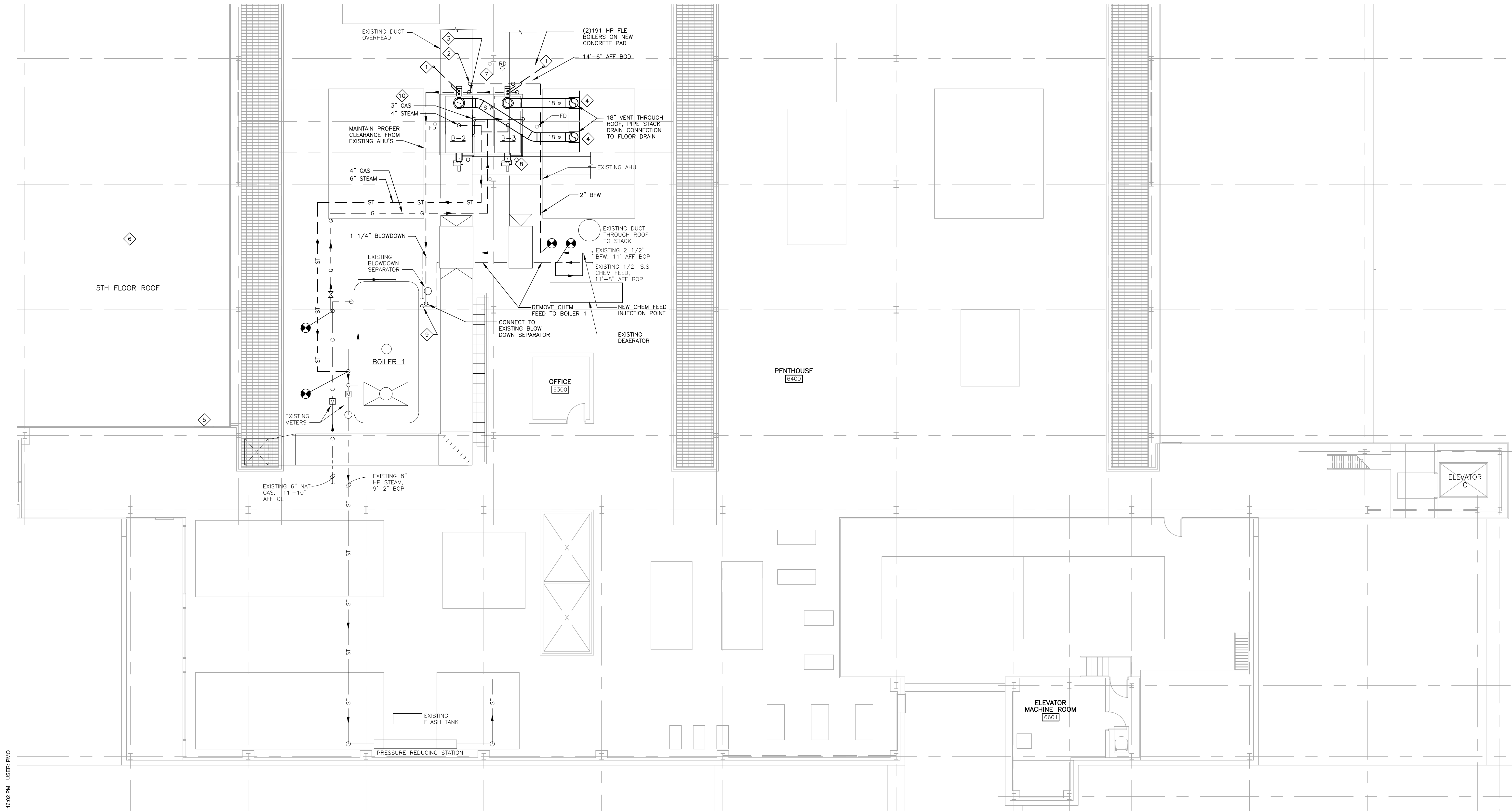
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PENTHOUSE MECHANICAL PLAN

SCALE: 1/8" = 1'-0"
0 4 8 16

NOTES

1. PROVIDE TRAPPED CONDENSATE LINES AT ANY LOW POINTS ON NEW STEAM PIPING. ROUTE TO EXISTING FLASH TANK NEAR STEAM PRESSURE REDUCING STATION OR NEAR DEAERATOR.
2. BOILERS ARE TO BE FIELD ASSEMBLED PER MANUFACTURERS INSTRUCTIONS. FREIGHT ELEVATOR IS TO BE USED FOR BRINGING PARTS TO PENTHOUSE EXCEPT FOR UPPER DRUM.
3. FIELD FABRICATED FITTINGS ARE UNACCEPTABLE.

KEY NOTES

1. PIPE PRV'S FULL SIZE THROUGH ROOF, SEE DETAIL.
2. 1 1/2" FEED WATER TO EACH BOILER.
3. ALL BLOW DOWN PIPING TO BE SCHEDULE 80 WITH EXTRA HEAVY WELDED OR FORGED FITTINGS AND 300# VALVES.
4. PROVIDE STEEL FRAME FOR OPENING (SEE DETAIL). FLASHING AND COUNTER FLASHING FOR 18" ROUND STACK PENETRATION. FLASH AND SEAL TO WEATHERTIGHT CONDITION. TO MAINTAIN ROOF WARRANTY, USE ROOFING CONTRACTOR RECOMMENDED BY OWNER FOR ALL ROOF FLASHING WORK.
5. USE EXISTING WALL ACCESS DOOR FOR RIGGING THE UPPER BOILER DRUM INTO THE PENTHOUSE.
6. BOILER UPPER DRUM (APPROXIMATELY 1,800 LBS) TO BE CRANED TO 5TH FLOOR ROOF. TAKE NECESSARY PRECAUTIONS TO PROTECT ROOF STRUCTURE AND ROOFING FROM DAMAGE. COORDINATE LIFT WITH OWNER REQUIREMENTS AND PROPER AUTHORITIES.
7. PROVIDE ACCESS PLATFORM AT THE END OF THE UPPER DRUM AS REQUIRED BY MICHIGAN BOILER RULES.
8. PIPE BOTTOM BLOW DOWN TOGETHER WITH UPPER BLOW DOWN. REFER TO BOILER INSTALL MANUAL AND SCHEMATIC.
9. REMOVE CHEMICAL FEED CONNECTION FROM FEED WATER PIPE AND PLUG IT. MOVE CHEMICAL FEED INJECTION POINT UPSTREAM OF NEW FEED WATER TO NEW BOILERS CONNECTION.
10. PROVIDE GAS SHUT OFF VALVE AT EACH BOILER GAS SERVICE LINE.



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Designer PMO
Reviewer GDM
Manager PMO

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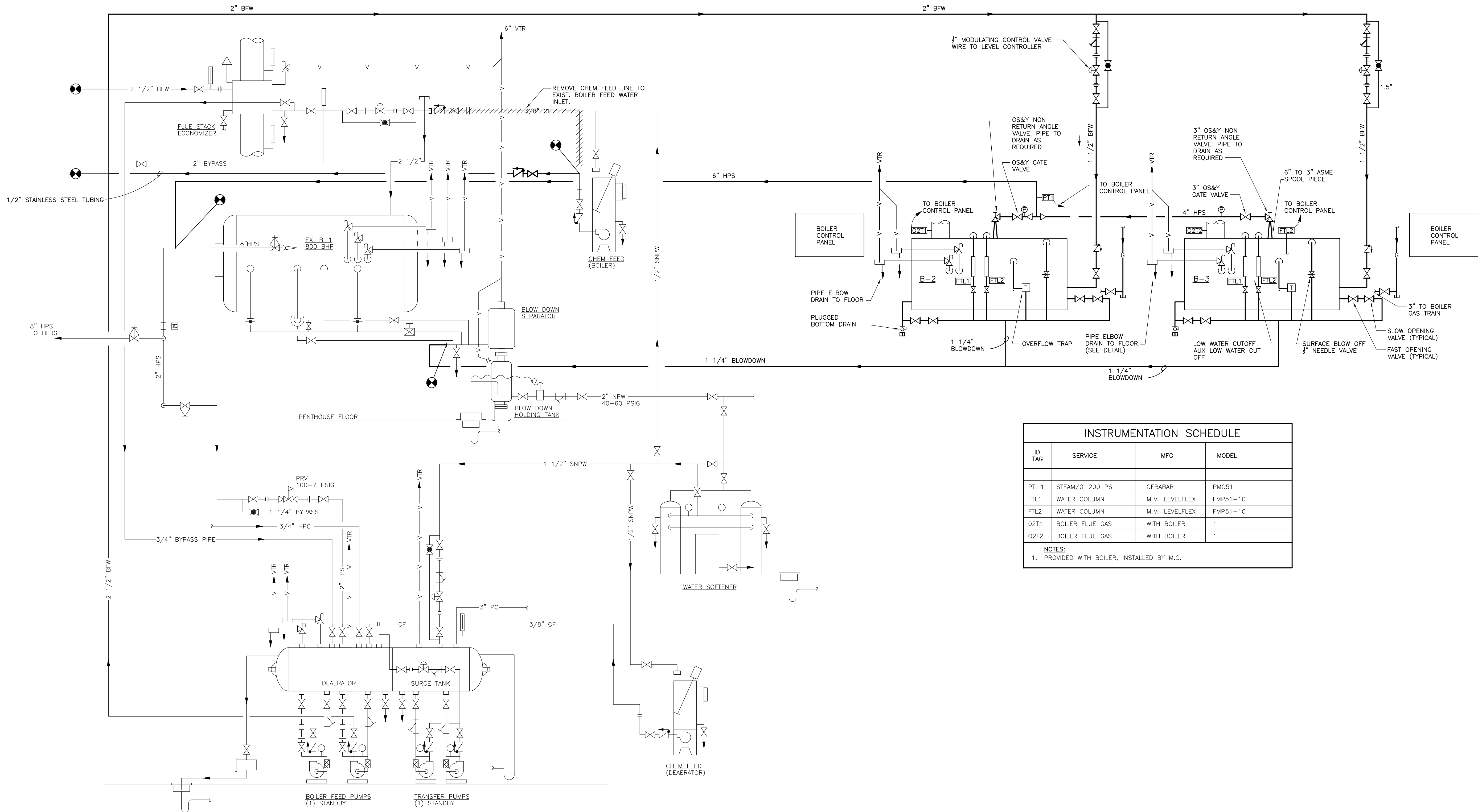
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| INSTRUMENTATION SCHEDULE | | | |
|--|-----------------|----------------|----------|
| ID TAG | SERVICE | MFG | MODEL |
| PT-1 | STEAM/0-200 PSI | CERABAR | PMC51 |
| FTL1 | WATER COLUMN | M.M. LEVELFLEX | FMP51-10 |
| FTL2 | WATER COLUMN | M.M. LEVELFLEX | FMP51-10 |
| OZT1 | BOILER FLUE GAS | WITH BOILER | 1 |
| OZT2 | BOILER FLUE GAS | WITH BOILER | 1 |
| NOTES: 1. PROVIDED WITH BOILER, INSTALLED BY M.C. | | | |

BOILER SYSTEM PIPING SCHEMATIC

NO SCALE

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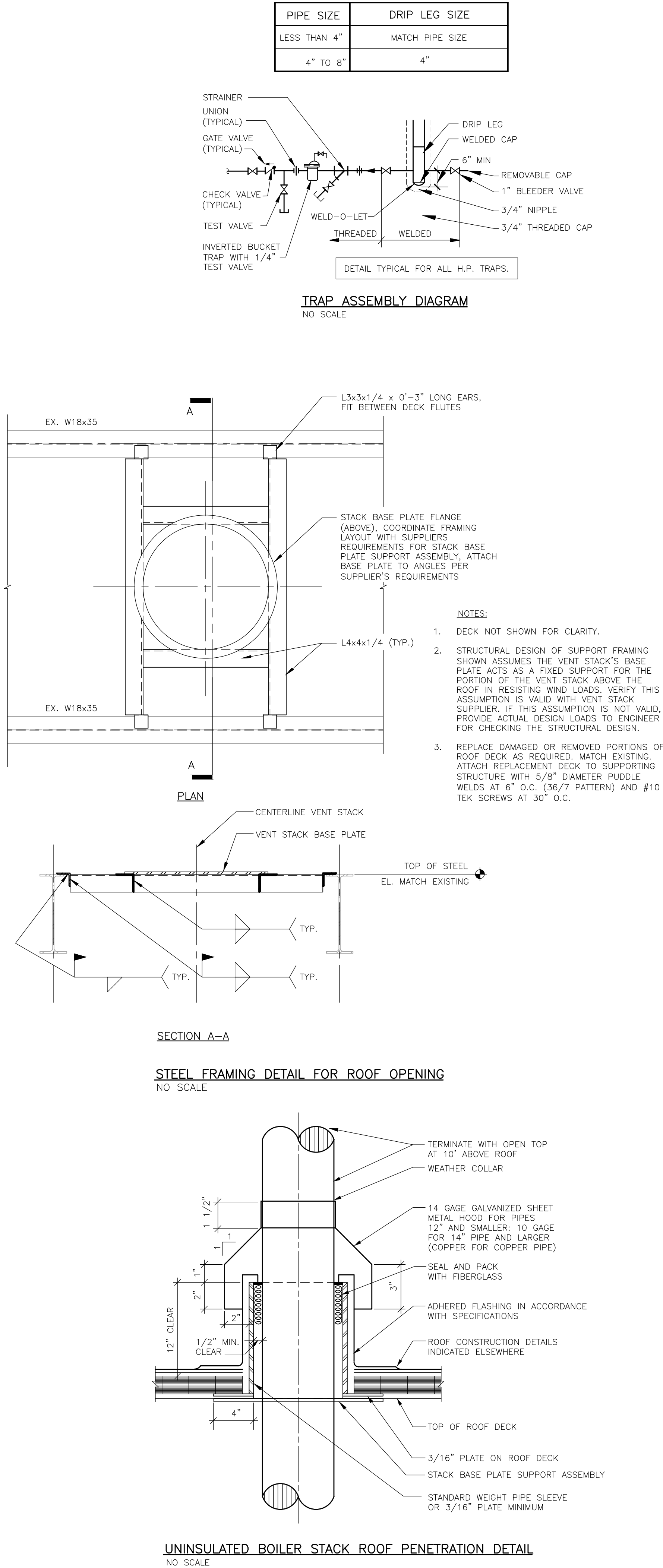
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| Drawn By | CEB |
| Designer | PMO |
| Reviewer | GDM |
| Manager | PMO |

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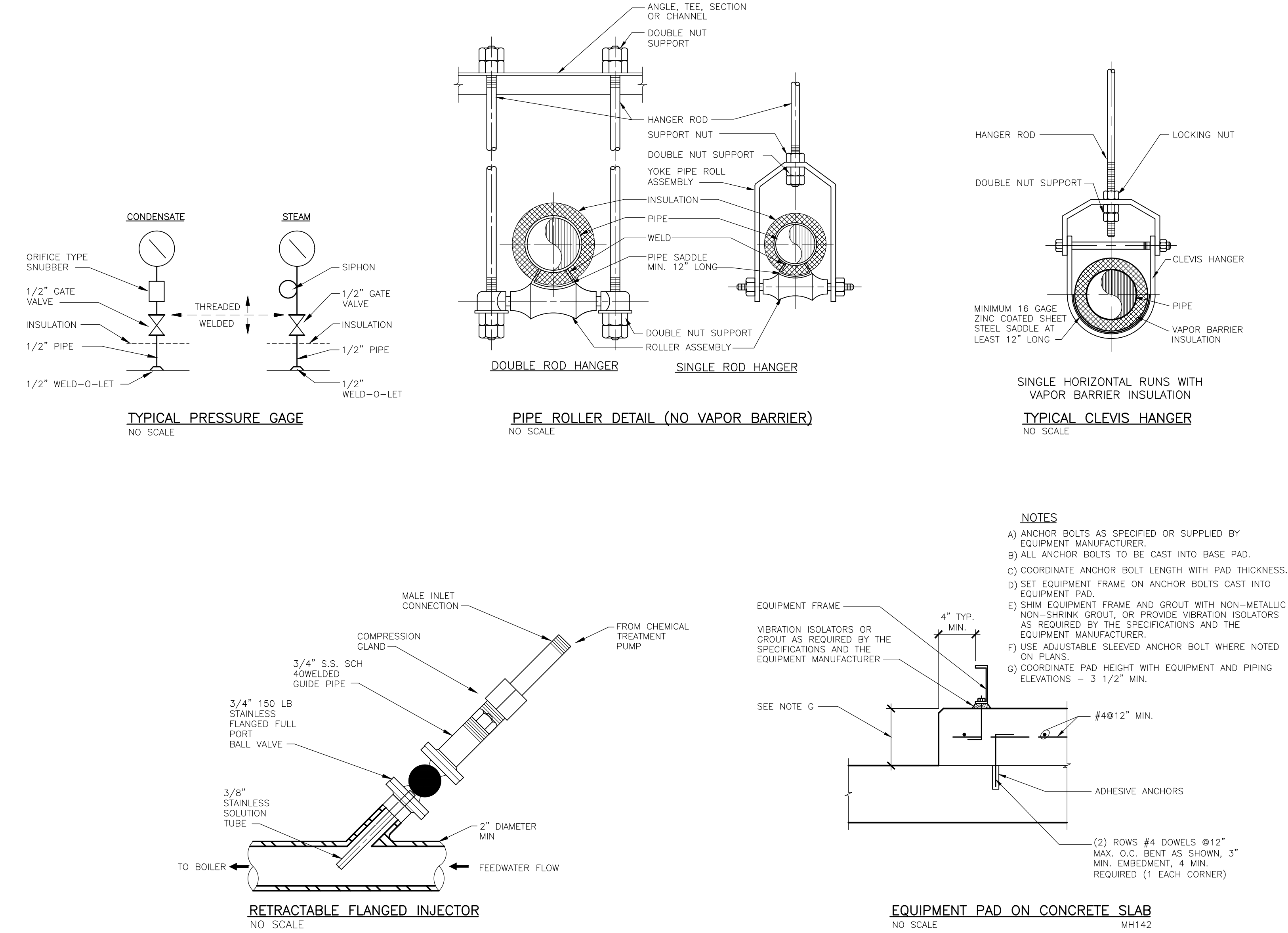
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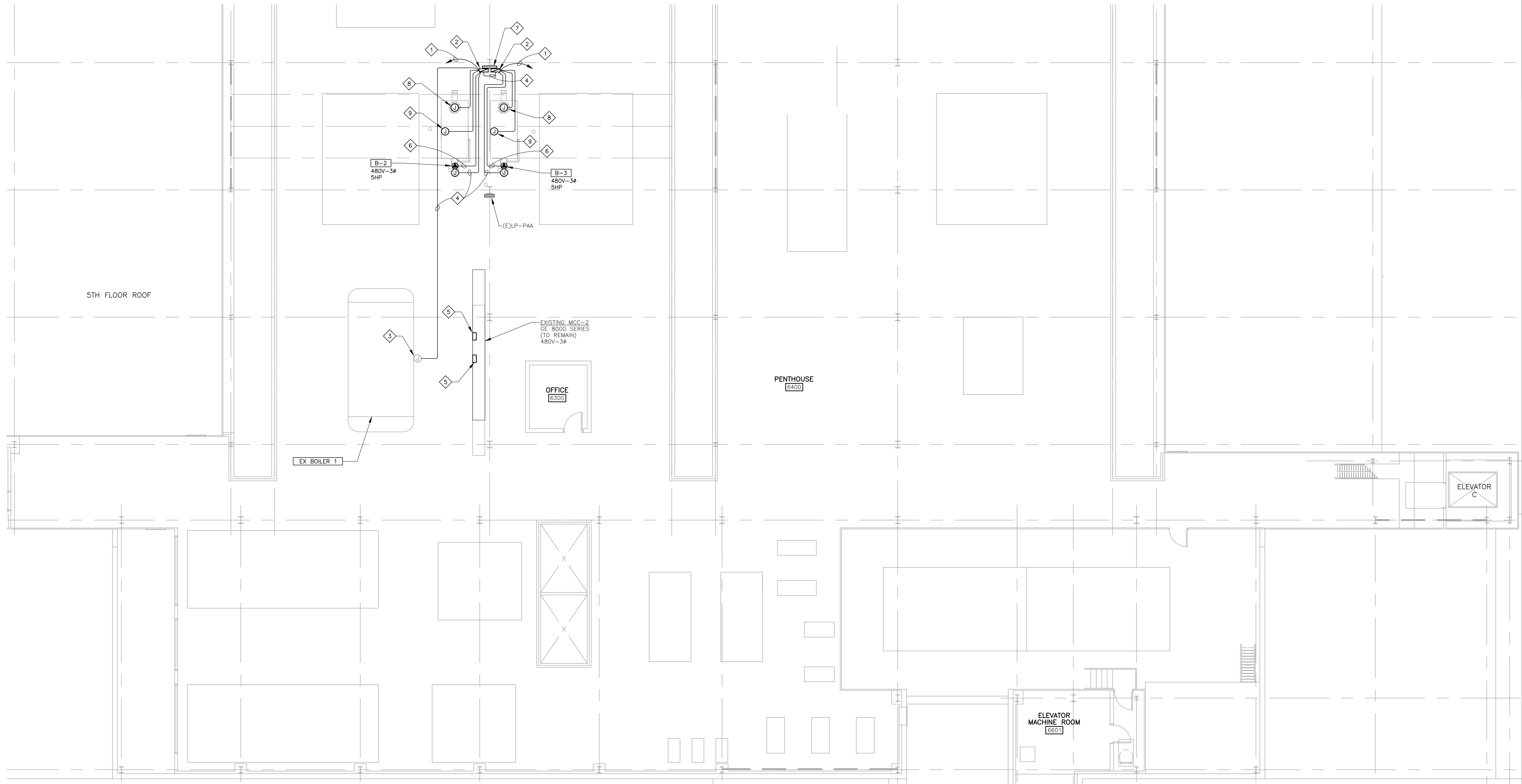
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| BOILER SCHEDULE | | | | | | | | | | | | | | | | | | | |
|--|----------------|-----------|---------|------------|-------------|--------|-----------|------------|------------------------|---------|-------------|----------------|--------------------|-------------------|------------|-------|------|----|------------------|
| ID TAG | MFG | LOCATION | MODEL | TYPE | PERFORMANCE | | | | MAX OPERATING PRESSURE | GAS CFH | MAX GAS PSI | TURNDOWN RATIO | EFFICIENCY AT 100% | EFFICIENCY AT 50% | ELECTRICAL | | | | OPERATING WEIGHT |
| | | | | | BHP | LBS/HR | INPUT MBH | OUTPUT MBH | | | | | | | VOLTAGE | PHASE | MCA | HP | |
| B-2 | CLEAVER BROOKS | PENTHOUSE | FLE 800 | WATER TUBE | 191 | 6,590 | 8000 | 6393 | 125 PSI | 7992 | 20 | 10:1 | 77.99 | 80.32 | 480 | 3 | 11.8 | 5 | 12,500 LBS |
| B-3 | CLEAVER BROOKS | PENTHOUSE | FLE 800 | WATER TUBE | 191 | 6,590 | 8000 | 6393 | 125 PSI | 7992 | 20 | 10:1 | 77.99 | 80.32 | 480 | 3 | 11.8 | 5 | 12,500 LBS |
| <div>NOTES</div> <div>1. EFFICIENCY BASED ON ASME PTC 4.1 HEAT LOSS METHOD.</div> <div>2. PROVIDE GAS REGULATOR TO REDUCE PRESSURE DOWN TO BOILER GAS TRAIN INLET PRESSURE OF 2.5 PSI.</div> | | | | | | | | | | | | | | | | | | | |



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PENTHOUSE ELECTRICAL PLAN

SCALE: 1/8" = 1'-0"
0 4 8 16

NOTES

- CONFIRM ALL WORK WITH MECHANICAL TRADES. COORDINATE ALL WORK AS REQUIRED.
- ALL NEW ELECTRICAL EQUIPMENT SHALL BE INSTALLED WITH PROPER CLEARANCES AS OUTLINED IN THE NATIONAL ELECTRICAL CODE AND THE SPECIFIC EQUIPMENT MANUFACTURERS' REQUIREMENTS.
- UPON COMPLETION OF PROJECT, OBTAIN RE-CERTIFICATION BY AUTHORITIES HAVING JURISDICTION, AS REQUIRED. INCLUDE ALL COSTS.
- ALL WIRING SHALL BE IN ACCORDANCE WITH THE WIRING DIAGRAM PROVIDED BY CLEAVER-BROOKS FOR THIS SPECIFIC INSTALLATION.

KEY NOTES

- 3#12, #12GRD, 3/4"C. TO NEW IN MCC-2.
- BOILER CONTROL PANEL WITH INTEGRAL DISCONNECT SWITCH. ELECTRICAL CONTRACTOR SHALL MOUNT CONTROL PANEL AS COORDINATED WITH MECHANICAL TRADES AND MANUFACTURER. FIELD CONFIRM.
- INTERCEPT EXISTING SHUT DOWN CONTROL CIRCUIT FOR THE EXISTING BOILER. TIE CONTROLS INTO EMERGENCY POWER OFF CIRCUIT. FIELD VERIFY EXACT LOCATION.
- TIE INTO EMERGENCY POWER OFF CURRENTLY SERVING EXISTING BOILER. UTILIZE 2#14, 1/2"C.
- PROVIDE A 100A FRAME, 15A TRIP, 3 POLE BREAKER IN A 1/2X (6") BUCKET RATED 25 KALC TO FIT IN AN EXISTING 6" SPACE. THE BREAKER SHALL BE ORDERED AS A COMPLETE REPLACEMENT BUCKET AND SHALL HAVE A THED STYLE BREAKER. COORDINATE SHUT-DOWN WITH WSU. ASSUME SHUT-DOWN TO OCCUR ON A PREMIUM LABOR RATE.
- 3#12, #12GRD, 3/4"C.
- PROVIDE AND INSTALL GALVANIZED UNI-STRUT AND HARDWARE TO MOUNT BOILER CONTROL PANELS ON COLUMN. FIELD CONFIRM.
- PROVIDE 1/2"C. FROM CONTROL PANEL TO VENT STACK PROBE. COORDINATE WIRING REQUIREMENTS WITH MANUFACTURER.
- PROVIDE 1/2"C. FROM CONTROL PANEL TO WATER LEVEL CONTROL. COORDINATE WIRING REQUIREMENTS WITH MANUFACTURER.



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